

New Scientist

WEEKLY 4 September 2021

BREAKING DOWN CONSCIOUSNESS

Anil Seth on how the greatest mystery will finally be solved

STRANGE WAVES

Could space-time ripples reveal quantum gravity?

MEAN STREAK

The surprising upsides of acting out of spite

YOUR NET ZERO LIFE

What our lives will actually look like when carbon emissions have been cut



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This week's issue

On the cover

34 Your net zero life

What our lives will actually look like when carbon emissions have been cut

10 Covid's origins

Urgent call for renewed focus on animal hypothesis



Vol 251 No 3350

Cover image: Simon Marchner

44 Breaking down consciousness

Anil Seth on how the greatest mystery will finally be solved

8 Strange waves

Could space-time ripples reveal quantum gravity?

40 Mean streak

The surprising upsides of acting out of spite

9 Caves on Mars

12 Ordinary space explosions

28 New Scientist photo awards

11 Domesticating baobabs

40 Features

“Social media cancelling allows us to climb the social ladder with a public display of ‘selfless’ virtue”

News

7 Hurricane Ida

Extreme storm almost certainly linked to climate change

9 Is it time for lunch?

Stroke left woman unable to feel hunger

13 Coining it in

Will Paypal adopting bitcoin help cryptocurrencies go mainstream?

Views

17 Comment

The UK doesn't need a new coal mine, says Mark Peplow

18 The columnist

Annalee Newitz on ancient money's links to the future

20 Letters

Sucking carbon from the air may be just the ticket

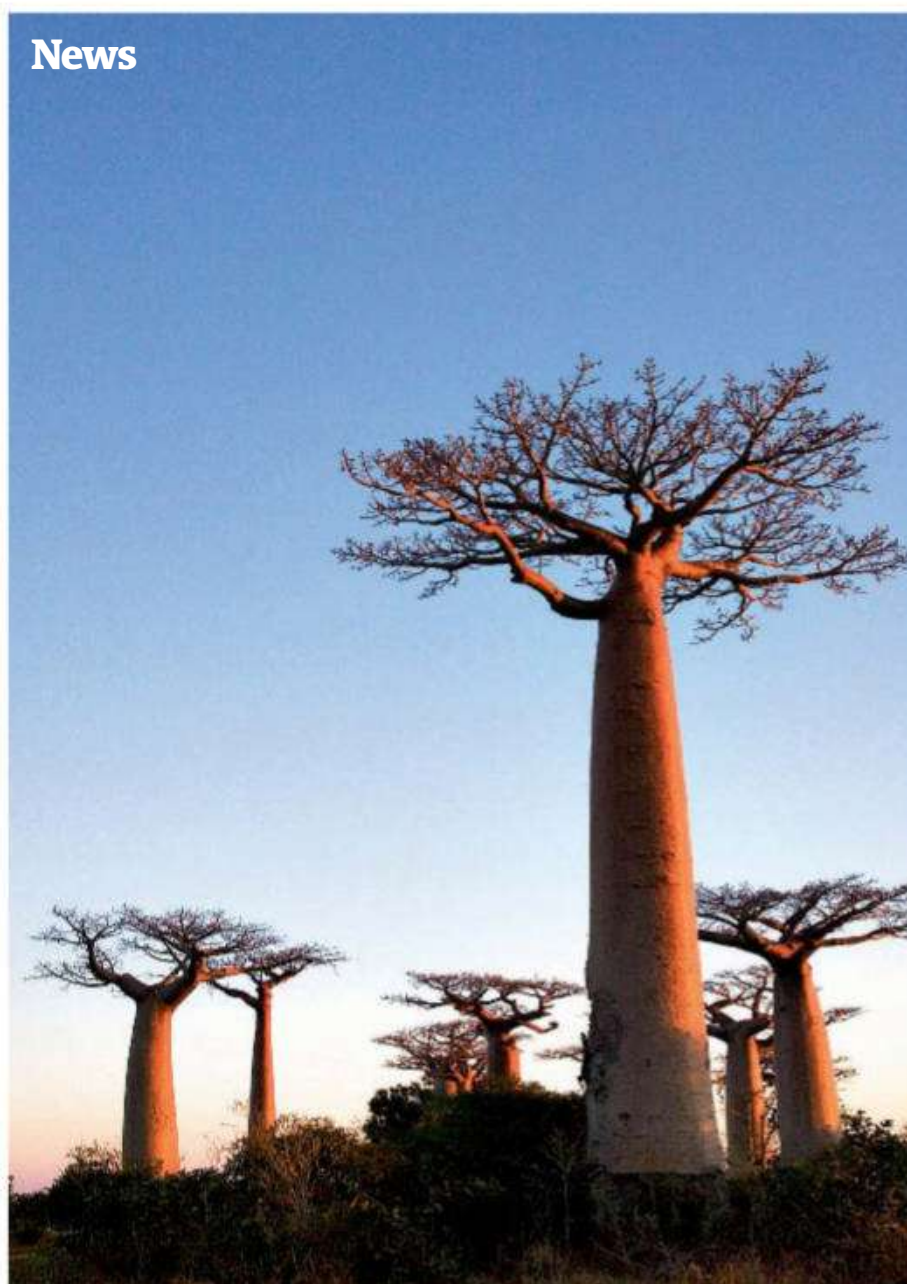
24 Culture

Stories from the International Space Station

28 Aperture

The pick of the pics from our inaugural photo contest

News



11 Home-grown baobab Domestication could save the iconic trees

KEREN SUJCHINA SPAN/LAMY

Features

34 A day in a net-zero life

How will the world look when we have taken the necessary steps to curb global warming?

40 The upsides of spite

Spitefulness is usually frowned upon, but there are times when it can do good

44 Consciousness, illuminated

A fulfilling way to solve the greatest mystery in science

The back pages

51 Stargazing at home

How to spot the ice giants Neptune and Uranus

53 Puzzles

Try our crossword, quick quiz and logic puzzle

54 Almost the last word

What would Earth be like if life had never existed?

55 Tom Gauld for New Scientist

A cartoonist's take on the world

56 Feedback

A study about truth that turned out to be untruthful

Academy

General relativity

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Online

Covid-19 daily briefing

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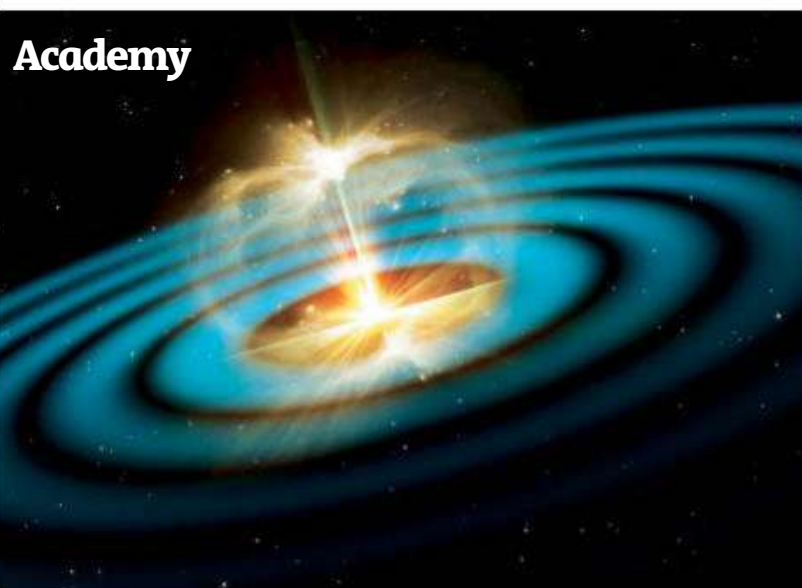
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Podcast

Weekly

Equipment from a massive biometrics programme in Afghanistan has been seized by the Taliban. The team explores the potential dangers caused by this development. Author Jeanette Winterson drops in to talk about *12 Bytes*, her new book on artificial intelligence. Plus: analysing a uranium cube used by the Nazis, pollen-stealing bees and 500 million never-before-seen asteroids.

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Ripples in space Discover the amazing science of gravitational waves



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Video

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Newsletter

Countdown to COP26

It is a huge year for climate negotiations, culminating in the international COP26 meeting in November. Adam Vaughan is counting down to it in this free, monthly newsletter. The most recent edition looks at how the Intergovernmental Panel on Climate Change's recent report will play into discussions.

[newscientist.com/sign-up/cop26](https://www.newscientist.com/sign-up/cop26)



Hello,
A few months ago on this page, I announced the launch of our inaugural *New Scientist* Photography Awards. I am delighted to say that it has been a resounding success. We had hundreds of brilliant entries and we have now whittled them down to 12 outstanding images.

To mention just a few, we have a woodlouse munching a slime mould that will take your breath away. As one of the judges, naturalist and TV presenter Chris Packham, said: "It's absolutely stunning. I like woodlice, but this is now my favourite ever woodlouse."

There is also an intimate depiction of lockdown life, showing the photographer's father celebrating his birthday with his relatives outside. A "very moving image", as our judge Sue Flood, an award-winning photographer, put it. And there is a kestrel family portrait that screams #AccidentalRenaissance. "Delightful," said Packham. A huge thanks to everyone who entered this year.

We now need your help. The panel has picked a winner for each of our three categories – The Natural World, Modern Life and Our Changing Environment – but the overall winner will be decided by the public. Head to page 28 to take a look at the best pictures, then visit [newscientist.com/publicvote](https://www.newscientist.com/publicvote) to pick your favourite.

Timothy Revell

Comment and culture editor



Good Things Foundation had the power to do more

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A greener tomorrow, today

We have the technologies to make a net-zero world. Now we must put them in place

“Yes we can.” Barack Obama’s political slogan is the perfect mantra for the net-zero targets that now apply to more than two-thirds of the global economy. As our feature imagining a day in a net-zero life demonstrates (see page 34), most of the technologies that are required to achieve those objectives already exist, or are in early development.

This isn’t an expression of unthinking, technophile optimism in the face of the dire findings of the Intergovernmental Panel on Climate Change (IPCC)’s recent report. We aren’t dismissing the technical, regulatory, economic and social challenges that will be involved in decarbonising buildings, transforming transport, upending diets and reshaping our landscapes.

Neither are we saying that it will be easy to remove the large amount of carbon dioxide from the atmosphere that the IPCC thinks we must do if we wish to avoid the climate impacts of a world that breaches 1.5°C of warming.

But what is clear is that the tools exist for countries to reach net zero by 2050.

“The costs of shifting to net zero must be weighed against the price of inaction”

We have the technologies and, increasingly, the right costs and scale. Wind and solar power can clean up electricity. Electrify almost everything, including heating and cars. Then pick truly green fuels – green hydrogen and more – for tricky stuff like heavy industry, trucks and ships.

How well governments pitch their policies to speed up the progress of these technologies will be key to winning buy-in from citizens that will shoulder the costs of the transition. The UK faces that test in coming weeks, with the publication of its net-zero strategy. The extreme weather of 2021 illustrates how the costs of shifting to net zero must be weighed against the price of inaction.

Politicians will also be aided by the fact that, as our feature spells out, a net-zero world should be a better one: healthier, cleaner, wilder. “Yes, we can” is the message for individual countries on the road to net zero. Can the whole world do it? This is the open question that leaders at the UN COP26 summit must address in two months’ time. ■

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Marketforce UK Ltd **Tel** +44 (0)33 0390 6555

Syndication

Tribune Content Agency **Tel** +44 (0)20 7588 7588

Email tca-articlesales@tribpub.com

Subscriptions

newscientist.com/subscription

One year print subscription (51 issues) UK £198

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Post New Scientist, Rockwood House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH

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© 2021 New Scientist Ltd, England. New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

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Opioid spike

Painkiller drug use rose in early days of pandemic **p8**

Mars below

Caves on Red Planet could be right for life **p9**

Marsupial return

Brush-tailed bettong is back on mainland Australia **p12**

Medical bias

UK ends kidney test adjustments based on ethnicity **p13**

The whole tooth

Bear mouth bacteria reveal history of antibiotics **p14**



SCOTT TOLSON/GETTY IMAGES

Environment

Hurricane Ida climate link

The storm, which has killed at least one person and left millions without power, was made worse by climate change, reports **Adam Vaughan**

HURRICANE Ida – which reached wind speeds of 240 kilometres per hour, killed at least one person and left more than a million people without power – was almost certainly made worse because of climate change, say scientists.

The category 4 storm intensified rapidly over the warm waters of the Gulf of Mexico before making landfall in Louisiana on Sunday, 16 years to the day since Hurricane Katrina – a category 3 storm – devastated the state. US president Joe Biden told reporters on Monday that one person had been killed, and more deaths were likely.

Studies that link extreme weather events like Ida to climate change take time, but past research has already connected

global warming with the heavy rainfall of 2017's Hurricane Harvey.

Tropical storms such as Ida are fuelled by the evaporation of seawater. August is already warm in the Gulf of Mexico, and the ocean's surface there was 0.3°C above the long-term average for the month.

"[Ida] moved over part of the Gulf of Mexico where the sea surface was really warm, so that was why it rapidly intensified," says Alex Baker at the University of Reading, UK. He says it is fair to draw a link between Ida's strength and climate change. "You probably can say that climate change made it more likely that part of the Gulf of Mexico was warmer, and so some of Ida's intensity might be

down to climate change," he says. "How much is difficult to quantify."

"Climate change didn't cause Hurricane Ida," said Katharine Hayhoe at Texas Tech University in Lubbock, on Twitter. "But it's virtually certain it made it worse."

Investment in infrastructure since 2005 has helped Louisiana escape some of the economic damage that resulted from Katrina, which exceeded \$160 billion.

Ida has disrupted the region's oil industry and left more than a million people in the state without electricity, once again highlighting the vulnerability of US energy grids to extreme weather. Texas's isolated electricity grid left millions without power during winter storms in February. ■

Climate change

Melting glaciers may spread viruses

CLIMATE change may increase the risk of viruses becoming capable of infecting new hosts in the Arctic. Canadian scientists have found that an increase in glacier melt at Lake Hazen, the Arctic's largest lake by volume, is linked to a greater risk of viral spillover, where a virus infects a new species for the first time.

Audrée Lemieux at the University of Ottawa and her colleagues gathered soil and sediment from the lake and sequenced the RNA and DNA in the samples. They found signatures of viruses and their possible hosts including animals, plants and fungi.

They then ran an algorithm that assesses the chance of coevolution or symbiosis among unrelated groups of organisms. The algorithm allowed the team to gauge the risk of spillover, and suggested that this was higher in lake samples nearer to the point where larger tributaries – carrying more meltwater from nearby glaciers – flow into the lake (bioRxiv, doi.org/gtbw).

"Our main finding is we show that for this specific lake, the spillover risk increases with the melting of glaciers. It's not the same thing as predicting pandemics – we're not crying wolf," says Lemieux.

The risk of infectious diseases emerging from the Arctic is low today, she says, due to the region's paucity of "bridge vectors", such as mosquitoes, that can spread viruses to other species. ■
Adam Vaughan

Cosmology

Waves in space-time could let us see if gravity is quantum

Leah Crane

WE MAY finally have a way to detect the quantum nature of gravity.

The question of how gravity and quantum mechanics fit together has been one of the biggest problems in physics for decades. The way that quantum fluctuations affect gravitational waves – ripples in space-time caused by the movements of massive objects – may give physicists a way to solve it.

Gravity is the one realm of physics that doesn't mesh with a quantum mechanical understanding of the universe. "Our fundamental physical theory is currently incoherent: it is made up of two parts that do not fit," says Carlo Rovelli at Aix-Marseille University in France, who wasn't involved in this work. "To have a coherent world picture we need to combine the two halves."

There has been a lot of theoretical work on this problem, but observations and experiments have yet to make a dent in it. This is mainly because the energy levels at which quantum effects on gravity's behaviour would be apparent are extraordinarily high. One place we find those high energy levels are in astronomical events that produce gravitational waves.

Waves produced by quantum fields, such as light, are by nature both waves and particles. So, if gravitational fields are indeed quantum fields, then gravitational waves should also behave as particles. Those hypothetical particles are called gravitons.

Now, Maulik Parikh at Arizona State University and his colleagues have calculated that the existence of gravitons could



create jitters in gravitational wave signals. They found that these could, theoretically, be detected with current gravitational wave observatories.

"Maybe the quantum nature of gravity is not so out of reach, and maybe there is an experimental signature of it," says Parikh. "Our prediction is that there's a kind of noise, a graininess, to gravity – and the features of that noise depend on the quantum state of the gravitational field."

"Our fundamental physical theory is incoherent: it is made of two parts that do not fit"

It could be distinguishable from other sources of noise, such as a truck driving past a detector, by the fact that it is likely to manifest as exactly the same fluctuations in the signal at multiple detectors simultaneously (*Physical Review Letters*, doi.org/gsvv).

Observing this noise would be proof that gravity is a quantum force. "We have all reasons to believe that this is the case," says Rovelli. "But

Gravitational waves may reveal particles called gravitons

in science we want hard empirical tests, not just 'reasons to believe'."

Parikh and his colleagues are now modelling what quantum noise would look like in real-life gravitational wave detections from astronomical events, such as merging black holes or neutron stars, so that we know what to look for.

Finding this signal and proving that gravity is a quantum phenomenon would be a major step towards unifying gravity and quantum mechanics.

Because gravity is a feature of all space-time and quantum mechanics describes matter, this would bring us closer to a self-consistent theory of everything in physics.

"The whole story of gravity is actually the story of space and time," says Parikh. "In a theory of everything, we would expect space and time and matter to be one in a sense, and observing this would be a step towards proving that." ■

Drugs

US opioid use spiked in the early months of the pandemic

Chris Stokel-Walker

USE of prescription opioids skyrocketed in parts of the US during the early stages of the coronavirus pandemic, while some illicit drug use decreased, according to an analysis of wastewater.

Bikram Subedi and his colleagues at Murray State University in Kentucky analysed wastewater from two communities in western Kentucky and northern Tennessee between March and July 2020.

"Wastewater has many different types of biomarkers that tell us a lot about what's going on in our community," says Subedi. "It's an almost near-real-time approach."

The samples were analysed for levels of 10 illegal drugs and 19 prescription drugs that are commonly abused. Between March and July, levels of the opioid-based painkiller hydrocodone in the wastewater increased by 72 per cent. Levels of prescription antidepressants rose between 7 and 40 per cent, depending on the drug, while anti-anxiety drugs like temazepam and alprazolam increased by nearly 30 per cent.

By comparison, the levels of methamphetamine and cocaine dropped 16 and 42 per cent, respectively (*Environmental Science & Technology Letters*, doi.org/gstb).

Subedi thinks that the decrease in drugs such as cocaine was caused by a tightening of travel restrictions and economic effects of the pandemic. "People could not get it, and they're expensive drugs," he says. "People couldn't afford it: people lost their jobs." Likewise, he believes the rise in prescription drugs found in wastewater was enabled by the shift to telemedicine making it easier to get prescriptions for opioids.

This kind of wastewater analysis is relatively new, but is a useful addition to public health analysis, says Wayne Hall at the University of Queensland, Australia. ■

Woman loses ability to feel hungry

A stroke in a mysterious brain area reveals its potential role in controlling how much we eat

Alice Klein

A WOMAN who lost the sensation of hunger after a stroke may help us explain how we regulate what we eat, and improve our understanding of one of the most mysterious areas of the brain.

The 28-year-old Canadian was hospitalised after feeling weak on one side of her body and having trouble speaking. Brain imaging showed that she had experienced a stroke in a brain area called the insular cortex.

Soon after the stroke, the woman noticed an aftertaste of iron whenever she ate anything. This resolved after a few weeks, but then she noticed that she never felt hungry any more, even when she hadn't eaten for a long time.

The woman often forgot to eat and lost more than 10 kilograms. "She had no way of knowing when it was time to eat and had to create a meal schedule," says Benjamin Hébert-Seropian at the University

of Quebec in Montreal, Canada, who wrote her case report (*Neurocase*, doi.org/gstj).

The woman could still taste, smell and sense the texture of food, but only tended to eat about half as much as usual because she no longer enjoyed eating. Even chocolate, her favourite food, gave her no pleasure. The woman's hunger finally came back about 15 months after the stroke.

Her case adds to emerging clues that the insular cortex – also known as the insula – is involved in the brain circuits that motivate us to eat, says Hébert-Seropian.

The insula is one of the least understood parts of the brain because it is tucked deep inside the folds of this organ. It seems to have a diverse set of functions, involved in consciousness, empathy and pain. But there is growing evidence that it also helps to process signals from different

parts of the body in order to assess our bodily state – for example, whether we are hungry or full, warm or cold, or tired or rested.

If the insula senses that something is out of balance – our blood sugar levels are too low, say – it tries to amend this. For example, it may work with other parts of the brain to create a

"You might want to reduce motivation for eating, but you risk turning people into listless zombies"

feeling of hunger that encourages eating, says Yoav Livneh at the Weizmann Institute of Science in Israel. "In this woman's case, her brain would still have been receiving signals that she was missing calories, but because of the damage to her insula she wouldn't have been aware of them," he says.

Hébert-Seropian and his colleagues have recently found that people who have their insulas removed to treat severe epilepsy can also have reduced appetite.

Together, these findings could pave the way for new weight-loss treatments for obesity, says Hébert-Seropian.

For example, it may be possible to use psychological techniques to improve people's understanding of their bodily signals and know when they are full, or to send electric currents to the insula to prevent overeating, he says.

Livneh agrees that this is a possibility, but says it will be important not to affect other behaviours that the insula helps to motivate. "You might want to reduce motivation for eating food, but you don't want to reduce motivation for other aspects of life because you risk turning people into listless zombies," he says. ■

Solar system

Martian cave entrances could be friendly for life

MOST of Mars is extremely inhospitable to life, but there may be a workaround. The areas near the entrances to Martian caves should, in theory, be shielded from some of the harmful radiation that bombards the planet's surface.

Because Mars doesn't have a global magnetic field or a thick atmosphere like Earth, its surface is exposed to dangerous ultraviolet (UV) radiation and ionising radiation from space, which would present a problem for native life and human explorers alike. Any living thing on the Martian surface would be exposed to doses of radiation that are 900 times higher on average



NASA/JPL-CALTECH/UNIV. OF ARIZONA

than those experienced on Earth.

However, images of the planet from orbit have shown what appear to be entrances to caves, and the insides of these caverns could be protected from those harmful rays. Daniel Viúdez-Moreiras at Spain's National Institute for Aerospace Technology has now calculated

how much UV radiation would still make it into different types of caves at various locations on Mars.

He found that in many cases the extent of UV radiation inside the caves would be around 2 per cent of that on the surface. Those radiation levels are low enough to be relatively safe, but still high

Mars has varied topography that might include caves in which life could survive

enough to sustain organisms that require light to photosynthesise (*Icarus*, doi.org/gsp8).

It isn't clear whether ionising radiation – which is potentially even more dangerous than UV – would be blocked out in the same way, but it is likely, according to Viúdez-Moreiras. "It is expected that ionising radiation will also be strongly attenuated in pit craters and cave skylights," he says.

Caves may be safe locations for human explorers to hide from the extreme conditions of the Martian surface, and they may also be some of the best places to search for signs of life on the Red Planet. ■

Leah Crane

Coronavirus

Where did covid-19 come from?

Scientists call for urgent investigation into the coronavirus's probable origin in animals

Adam Vaughan

THE window of opportunity to establish the origins of SARS-CoV-2 will close within months if action isn't taken soon, warn scientists tasked by the World Health Organization (WHO) to discover how the virus emerged.

In a wide-ranging comment article in the journal *Nature* (doi.org/gspz), the team calls for a second phase of origin studies to start urgently and asks for renewed focus on an animal origin of the virus, rather than a leak from a laboratory. The group also defended its work, which in March concluded that a lab leak was "extremely unlikely", but has received criticism from some governments and commentators.

"We wrote [the article] because the clock is ticking and time is passing," says Marion Koopmans at the Erasmus University Medical Center in Rotterdam, the Netherlands, who was part of the team that visited Wuhan, China, in January to explore the origins of the virus. "We feel a sense of urgency is missing."

Waning covid-19 antibodies in the first people infected by the virus and the culling of animals at Chinese wildlife farms are two reasons why the "window is rapidly closing on the biological feasibility" of tracing the virus back to where it started, the group says. Asked how long remains to identify the virus's origin, Koopmans says it is a matter of months, not years.

The article comes after WHO director-general Tedros Adhanom Ghebreyesus called in July for a second phase of studies into the virus's origins, including an audit of processes at laboratories such as the Wuhan Institute of Virology,

which researches coronaviruses. The Chinese government rejected the proposal, claiming it showed "arrogance towards science".

A separate report by US intelligence on the origins of covid-19, which was requested by US president Joe Biden and

"We should not lose sight of the animal origin hypothesis, which we have concluded is most likely"

ordered to explore the possibility of a lab leak, was published last week. The report was inconclusive, with intelligence agencies divided on the most likely origin of covid-19.

Koopmans says the spotlight must be put back on what the team concluded is SARS-CoV-2's most likely origin: an animal virus moving into humans through a direct contact or an intermediary,

either at the Huanan seafood market in Wuhan or at another step of the wildlife trade.

The group feels that discussions by WHO member states regarding the first report are taking too long and are too narrowly focused on the lab-leak hypothesis.

"We should not lose sight of the other hypothesis, which we have concluded is the most likely," says Koopmans. A paper published in July strengthened the case for the animal origin, she adds.

The team also says that no data supporting a lab-leak hypothesis has yet been submitted to the WHO, despite repeated calls for it. A researcher who has spoken with the authors of the *Nature* article but wishes to remain anonymous says that one reason for the article was that the team members felt they needed to defend their reputations, and also because they felt sidelined by

Ghebreyesus's focus on lab leaks.

The article goes on to suggest that the WHO's goalposts shifted during the initial inquiry. For example, the WHO's original terms of reference didn't include asking Chinese researchers to hand over raw patient data. The WHO requested the data while the first phase of the inquiry was under way.

The article states that researchers in China are "reluctant" to share the raw data on 174 covid-19 patients identified in December 2019 because of patient confidentiality. "It's easier said than done," says Koopmans.

Restricted access

The team has set out six priorities for the next phase of studies into the origins of SARS-CoV-2, including looking for further human covid-19 cases from late 2019. Following the ease with which covid-19 circulated in farmed mink in Denmark, the team also wants to see surveys on possible covid-19 hosts or intermediaries, including wild bats and "high-risk" farmed animals, such as badgers and civets.

Chris Beyrer at Johns Hopkins University in Baltimore, Maryland, who isn't part of the inquiry, says: "Their first message is they acknowledge they have not had access to all the data, to the earliest clinical cases, to all the animal data – and that's critically important."

At the start of the 2003 SARS epidemic, when it was clear that the virus involved the wildlife trade and mixing of species that wouldn't normally encounter each other in nature, China's government was unwilling to release data. "China took two years to release the first 50 people's data," says Beyrer.



HECTOR RETAMAL/AFP VIA GETTY IMAGES

A wet food market in Wuhan in China's Hubei province

Efforts to domesticate African baobab trees are bearing fruit

Michael Le Page

“The [*Nature*] article implies that China has not been fully cooperative in terms of being transparent in the probe,” says Yanzhong Huang at the Council on Foreign Relations, a think tank based in New York City. “I think it will have an impact, through the strong message on the urgency of conducting phase two of the investigation.” The Biden administration is supportive of a second phase.

The WHO commented on the *Nature* article, saying in a statement: “They have done important work before and during their mission to Wuhan to advance our knowledge on the origin and their work will be valuable for the next steps in looking for the origin of this virus.”

A conflict of interest statement accompanying the article notes that one of the authors, Peter Daszak at EcoHealth Alliance in New York City, has previously conducted studies with the Wuhan Institute of Virology, the facility at the centre of the lab-leak hypothesis.

The paper is written solely by the inquiry’s 11 external scientists. That doesn’t include Peter Ben Embarek at the WHO, who has worked on the inquiry and fronted a February press conference on the team’s initial findings. “It’s not a sign of disagreement,” says Koopmans of his omission.

David Heymann at the London School of Hygiene & Tropical Medicine, who led the WHO response to SARS in 2003, says he hopes scientists in and outside China will continue to work together, though it remains unclear if the virus’s source can be found at this stage. “The collaboration that has been started has been really important,” he says. ■

THE famous African baobab tree is being domesticated. Farmers seldom plant baobabs because they take between eight and 23 years to flower – and potentially begin bearing fruit – but a pair of researchers in Ghana have got them to flower in less than three years.

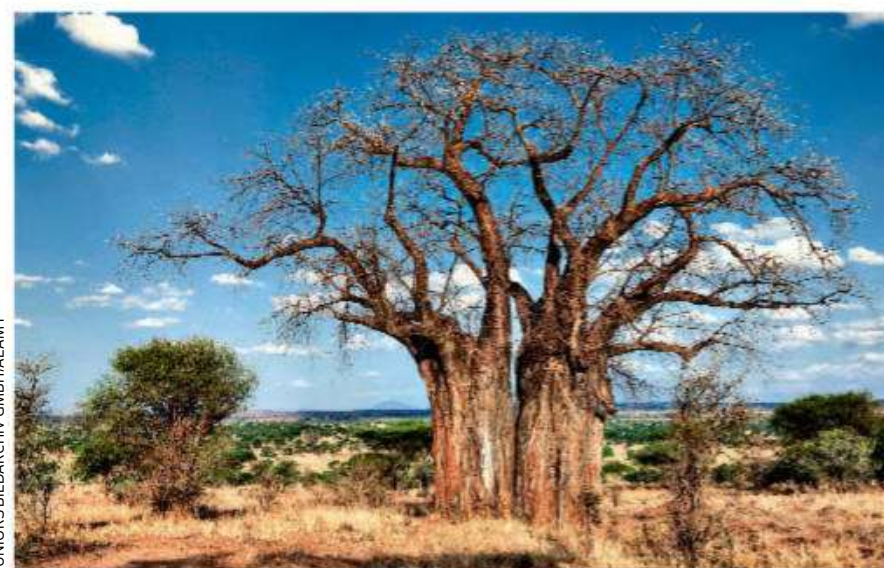
The work could lead to plantations of baobabs springing up all over Africa. “That is our vision,” says Kenneth Egbadzor at Ho Technical University in Ghana. “What we need now is funding.”

In parts of Africa, *Adansonia digitata*, known as the African baobab tree, is already an important food source. Its fruit, seeds, leaves, flowers and roots are edible. Fibre from the bark is used to make mats, ropes and hats, and every part of the tree is used in traditional medicines.

The pulp of the fruit has been approved as a food in the US and Europe in recent years, where it is being promoted as a “superfood”, so the fruit is now exported too. However, all harvesting is still done from wild trees. “There are no known commercial plantations,” says Egbadzor.

Domesticating the baobab has long been seen as an important goal. Widespread cultivation of the trees would diversify farming and improve food security, say Egbadzor and his colleague Jones Akuaku, also at Ho Technical University. This is especially important in a changing climate. Baobabs store water in their trunks and can keep fruiting during droughts. Because of the value of baobab products, farmers would also be able to earn more money, alleviating poverty, the pair say.

In recent years, various teams have tried methods such as grafting – widely used for fruit production globally – to speed



JUNIORS BILDARCHIV GMBH/LAMY

up the fruiting process, and Egbadzor and Akuaku have achieved the best results yet.

The pair soaked the baobab’s tough seeds in acid to get them to germinate. When the seedlings were seven months old, branches from mature trees that were already fruiting were grafted onto the seedlings.

The first tree started flowering 20 months later, when it was just 1.7 metres high (bioRxiv,

27 months – the age at which one baobab began flowering

doi.org/gstg). The results should encourage farmers to plant baobabs, says Egbadzor.

“Without doubt, I can say that baobab is becoming effectively domesticated, because different ways of propagating the species are being mastered,” says Kolawolé Valère Salako at the University of Abomey-Calavi in Benin. Egbadzor and Akuaku’s results are the best so far, says Salako, but need to be repeated to ensure they are consistent and scalable.

Domestication will contribute to the protection of the tree, says Dietrich Darr at Rhine-Waal

An African baobab tree (*Adansonia digitata*) in Tanzania

University of Applied Sciences in Germany, who leads a project to encourage the use of the baobab.

“Increasing commercialisation in some areas is increasing the pressure on the [wild baobab] resource,” he says. “The long-term ambition is to develop agroforestry systems including baobabs and some other crops in order to release pressure on these natural baobab stands.”

But it is possible to exploit wild baobabs in sustainable ways, says Darr. There are also still vast areas in Africa where baobabs aren’t intensively utilised, he says.

Many of the oldest and largest baobabs in Africa have recently died off, probably as a result of climate change, a study reported in 2018. Some of the trees were more than 2000 years old. The species isn’t regarded as threatened, but numbers are declining in places.

Protecting wild baobabs will remain important even if baobabs are widely cultivated, says Egbadzor. “The natural variability has to be conserved even after domestication.” ■

Conservation

Marsupials reintroduced

The brush-tailed bettong is returning to the Australian mainland

Alice Klein

A SMALL, endangered marsupial has been reintroduced to mainland South Australia after disappearing from the region more than a century ago.

The brush-tailed bettong, or woylie (*Bettongia penicillata*), once occupied more than 60 per cent of Australia, but was almost wiped out when cats and foxes were introduced by Europeans. It has survived only on predator-free islands. On 17 August, 12 male and 28 female bettongs were returned to mainland South Australia.

They were released in an area containing large tracts of native vegetation. Three-quarters of the animals were fitted with radio-tracking collars so their progress could be monitored.

"Some are already dispersing from the release site," says Derek Sandow at the South Australian government's Northern and Yorke Landscape Board. ■



WWF-AUSTRALIA/JUANSIMAGE.COM



Cosmology

Cosmic rays from an 'ordinary' star explosion

HIGH-energy cosmic rays may be released during commonly occurring stellar explosions. The discovery suggests these explosions can sometimes be more powerful than we believed.

Galactic cosmic rays – particles that move at close to the speed of light – are nearly always accompanied by very high-energy gamma radiation. This co-occurrence is helpful because cosmic rays are deflected by magnetic fields before they reach Earth, making it difficult to work out where they came from. But the gamma radiation isn't deflected, so it is easier to establish its source – and hence also the source of the cosmic rays.

Stefan Wagner at Heidelberg University in Germany and his colleagues have been studying such gamma rays using the High Energy Stereoscopic System – a global system of telescopes.

On The Astronomer's Telegram, a website used by researchers to communicate new findings rapidly, Wagner's team reports the discovery of high-energy gamma radiation coming from a single source called RS Ophiuchi in the constellation Ophiuchus, about 5000 light years away from Earth.

RS Ophiuchi consists of a white dwarf and a red giant, and the white dwarf temporarily brightens in a "nova" explosion about once every 15 to 20 years. A closer look

suggests the high-energy gamma radiation was released during one of these nova explosions.

Novae are a lot smaller than supernovae – which happen when a star dies – but the new discovery suggests that some novae may be far stronger than we believed. The radiation released during the nova in RS Ophiuchi was between 10 and 100 times stronger than that associated with any nova previously studied.

"We've looked at nova outbursts for the last few years and never

seen high-energy gamma radiation," says Wagner. "This is the first detection."

Wagner says the particles, along with the radiation released, will give us a better idea of what happens inside a nova explosion.

Brian Metzger at Columbia University in New York City says it is an important finding, though he notes that most high-energy cosmic rays are still likely to come from supernovae. He also says it is unclear whether other novae also release cosmic rays.

"We need to get lucky to catch more gamma-ray bright classical novae to address this question in the future," he says. ■

Jason Arunn Murugesu

"This is the first detection of high energy gamma radiation from a nova outburst"

UK ends guidance to adjust kidney tests based on ethnicity

Loyal Liverpool

CONTROVERSIAL guidance to adjust kidney test results based on a person's ethnicity has been removed from UK medical guidelines.

Kidney function is routinely assessed using an equation that estimates the rate at which a person's kidneys filter waste, called their estimated glomerular filtration rate (eGFR). Until 25 August, guidelines from the UK's National Institute for Health and Care Excellence (NICE) recommended applying "a correction factor to GFR values... for people of African-Caribbean or African family origin". Now, this recommendation has been removed.

The updated NICE guidance comes as a growing number of doctors and researchers have been questioning the use of race and ethnicity adjustments in medical tests and highlighting the lack of evidence to support their use and the potential harm they can cause.

A recent study led by Rouvick Gama and Kate Bramham at King's College Hospital in London found that the use of ethnicity adjustment in eGFR equations overestimates actual GFR in Black people by about 25 per cent. This may lead to reduced diagnosis of chronic kidney disease and underestimation of disease severity among Black people in the UK, they concluded.

"Ethnicity and race are social constructs and do not match genetic categories," says Paul Cockwell, president of the UK Kidney Association. "Adjusting for kidney function based on ethnicity could lead to an overestimation of kidney function and potential inequality in delivery of care."

NICE told *New Scientist* the change was "due to a number of variable factors in the evidence which meant it was more appropriate to take into account individual risk factors". ■

Will PayPal make bitcoin more mainstream? The company now allows cryptocurrency sales in the UK, but there are still hurdles to its everyday use, reports **Matthew Sparkes**

PAYPAL has two decades of experience in online payments and manages 403 million user accounts. So, it caused ripples when it announced on 23 August it would allow UK customers to buy and sell four cryptocurrencies: bitcoin prices rose to a three-month high. But will this – and last October's roll-out in the US – push cryptocurrencies into the mainstream, or is it just another blip in the short but volatile history of decentralised money?

Customers in the US who have bought cryptocurrencies through PayPal log in twice as often as those who haven't, says Jose Fernandez da Ponte at PayPal. "We expect digital currencies to play an important role in consumer payments over the longer term," he says.

Public interest in bitcoin and other cryptocurrencies is certainly growing, but only a minority have bought in. A YouGov survey revealed that by August 2019, just 3 per cent of people in the UK owned any cryptocurrencies. By July 2021 that had risen to 8 per cent.

Giving millions of existing PayPal customers the ability to buy at the click of a button has enormous potential for increasing those numbers, but access to the currency isn't the only limiting factor. People need a way to spend it.

A handful of large companies, such as Microsoft, have begun accepting bitcoin as payment, and others such as electric car company Tesla have done so at times too. And while several other retailers, including grocery stores, coffee shops and

hardware stores, have systems to accept cryptocurrency in some countries, using only this form of payment day-to-day would be no easy task.

PayPal users in the UK won't be able to use cryptocurrency to buy goods or services – they can only buy, hold and sell the currency. But in the US, the company offers the ability to use balances for payments anywhere that accepts PayPal. This effectively allows hundreds

8%

Proportion of people in the UK that own cryptocurrency

of thousands of retailers to accept cryptocurrencies without having to make any changes or accept any risk, and receive US dollars from PayPal as normal.

This is vital, as the risk for businesses is high, says Carol Alexander at the University of Sussex, UK. Cryptocurrencies are "dominated by huge speculation and rampant manipulation", she says.

Organised groups are able to cause swings in cryptocurrency values with coordinated buying or selling and, unlike the traditional financial services

sector, there is little regulation to stop it. So, if you take bitcoin as payment directly, it may plummet in value before you convert it.

"I can't see this as the moment crypto goes mainstream. The widespread market abuse needs addressing first," says Alexander.

Cryptocurrencies are decentralised systems with no official oversight, so regulation is difficult. Registered companies that deal in them are finding themselves under increasing scrutiny. In June, the UK's Financial Conduct Authority ruled that Binance Markets Limited, one of the world's largest cryptocurrency exchanges, had to cease regulated trading in the UK.

There are still hurdles to overcome before cryptocurrency can truly break into the mainstream, including its exorbitant energy use, volatility and complexity.

But some are still confident that the technology offers enough benefits, such as protection from inflation, a degree of anonymity and low fees for large payments, that widespread adoption is inevitable.

Nigel Green at financial services firm deVere Group is confident that cryptocurrencies will replace traditional money and, although that moment is still some way off, he says PayPal's announcement is "yet another example that exposes cryptocurrency deniers as being on the wrong side of history".

"This is a major step forward towards the mass adoption of digital currencies," he says. "More and more payment companies will naturally follow their lead." ■



Through PayPal, cryptocurrency can be used at US retailers



ONDREJ PROSICKY/GETTY IMAGES

Antibiotics

Antibiotic resistance tracked in wild bears' tooth plaque

THE mouth bacteria of wild bears in Sweden hold a historical record of human antibiotic use and the rise of antibiotic resistance.

Antibiotics are used in medicine and agriculture, and can leak into the environment via untreated waste water. Wild animals can then encounter contaminated water, soil or food sources, and play a role in the evolution of antibiotic resistance.

To track changes in antibiotic resistance over time, Jaelle Brealey, then at Uppsala University in Sweden, and her team sequenced the oral microbiomes of Swedish brown bears (pictured), using museum specimens dated from 1842 to 2016. They did this by extracting genetic material from the hardened tooth plaque of each bear. "This is bacteria that we brush off every morning and every evening

when we clean our teeth," says team member Katerina Guschanski, also at Uppsala University, "but bears don't have oral hygiene."

They found that the presence of antibiotic resistance genes in the bear samples mirrored records of human antibiotic use. An initial low level of natural antibiotic resistance nearly doubled after large-scale industrial production of antibiotics began in the 1940s (*Current Biology*, doi.org/gspw). The finding shows how much antibiotics have contaminated the natural world, says Brealey, "to the point where we can see it in a wild animal that isn't closely associated with humans".

The team also found a fall in the prevalence of resistance genes over the past 20 years, coinciding with Sweden implementing mitigation policies. **Charlotte Hartley**

Environment

China's lockdowns caused early spring

CHINA's strict covid-19 lockdowns last year curbed air pollution in many cities in a short-lived clean-up estimated to have avoided thousands of deaths. Now, it appears the clearer skies also brought forward China's spring bloom by around eight days.

Fenzhen Su at the Chinese Academy of Sciences and his team used cellphone location data from technology firm Baidu as a proxy for how much people in large cities were moving around between January and April 2020. Movement dropped by more than half on pre-pandemic levels between 23 January and 9 February, and only began to recover to near-normal levels in mid-March.

The team combined this with data on nitrogen dioxide – an air pollutant mostly produced by cars – and satellite data on the haziness of the air, the extent of

leaf cover and how much sunlight was getting to vegetation for photosynthesis.

The spring months of 2020 were found to have more sunlight than previous years, with the biggest relative change occurring between January and February – the same time as the peak of covid-19 restrictions.

Across China as a whole, there was estimated to be 17 per cent more "greenness" than the five previous years, as measured by an index of leaf cover per unit of land. Based on that index, the spring bloom arrived 8.4 days earlier than the average date of 6 April for 2015 to 2019 (*Science Advances*, doi.org/gsqd).

The authors say the timing of the changes in relation to lockdowns suggests that the drop in air pollution boosted photosynthesis. They say their findings are evidence for the speed with which nature can bounce back when human pressures are lifted. **Adam Vaughan**

Health

Gene discovery may help endometriosis

ENDOMETRIOSIS-like symptoms in mice can be treated by targeting a gene linked to the condition.

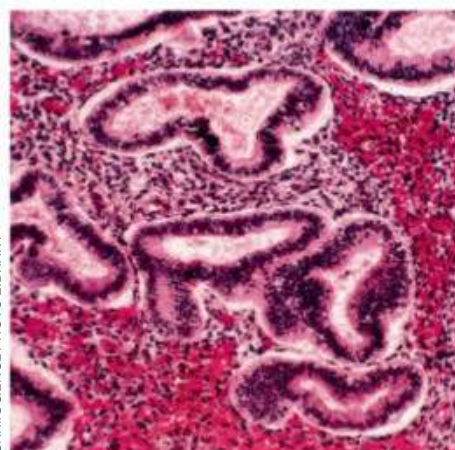
Endometriosis occurs when tissue from the uterus spreads to other areas like the ovaries (pictured) and bladder. It affects up to 1 in 10 women and can cause intense pelvic pain and infertility.

Thomas Tapmeier at Monash University in Melbourne, Australia, and his team studied

100 women with endometriosis who each had several relatives with the condition, hinting at a genetic influence. About a quarter of the women had variations in a gene called *NPSR1*. Analysis of another 3000 women with the condition showed that those with moderate to severe disease were also more likely to have variations in the *NPSR1* gene.

To see if targeting *NPSR1* could help to treat endometriosis, the researchers gave female mice endometriosis-like symptoms by implanting uterus tissue in other parts of their pelvises. They then treated them with a molecule called SHA 68R, which inhibits the receptor encoded by *NPSR1*.

The treated mice appeared to have less abdominal pain and had lower levels of inflammation than untreated mice (*Science Translational Medicine*, doi.org/gsp7). This hints that targeting *NPSR1* may also help women with endometriosis, says Tapmeier. **Alice Klein**



CNRI/SCIENCE PHOTO LIBRARY



Really brief



VICTOR BECCARI

Pterosaur's crest made flying difficult

A 100-million-year-old pterosaur had a 50-centimetre-tall head crest that must have made flying long distances a challenge, say palaeontologists. *Tupandactylus navigans* stood about 1 metre tall, with the crest accounting for half its height (*PLoS One*, doi.org/gsn8).

Apple iPhone may disrupt pacemakers

Magnets inside an iPhone might trigger a pacemaker to no longer "listen" to the heart's natural rhythm, potentially causing harm. The "magnet mode" is only meant to be activated by medics, but an iPhone may activate it too. Apple does alert consumers about the problem (*Heart Rhythm*, doi.org/gsn9).

MRI can now reveal epigenetic changes

It is now possible to study epigenetic changes to DNA in the brain using an MRI scan. The technique, trialled in piglets, involves eating a diet that labels so-called methyl groups in a way that can be detected with MRI. Methyl groups attach to DNA and change its behaviour epigenetically (*bioRxiv*, doi.org/gspc).

Surgery

Gel could help treat damaged joints

A HYDROGEL could help improve the treatment of damaged cartilage in knees and other joints. The gel, which provides a scaffold for cartilage cells to grow on, can be implanted via keyhole surgery.

Treating cartilage injuries is difficult because the tissue doesn't heal well, if at all, in adults. It is possible to try to repair cartilage by implanting cartilage cells to regenerate damaged areas. While this has been done since 1987,

there are many difficulties.

One challenge has been firmly fixing the cells in the damaged area, says Qiuning Lin at the Shanghai Jiao Tong University in China. The gel her team has developed may solve the problem.

The gel doesn't set until exposed to ultraviolet light for around 10 seconds and then does so quickly. It also binds strongly to surrounding cartilage and maintains its shape over the months required for new cartilage to grow. It can be applied during keyhole surgery and keeps cells in place once set.

In tests in pigs, cartilage defects were well-healed six months after the gel, loaded with cartilage cells, was applied. When the gel was applied without these cells, there was little healing (*Science Advances*, doi.org/gsqg).

The animal studies involved treating damaged cartilage that covers the end of bones. However, many knee injuries involve damage to the meniscus, the cartilage that sits in between the bones. Further animal studies would be needed to establish if repairing the meniscus is feasible, says Lin. **Michael Le Page**

Human evolution



UNIVERSITY OF HASANUDDIN

Did humans meet mysterious Denisovans in Indonesia?

DNA from the bones of a Stone Age woman who lived on the Indonesian island of Sulawesi is shedding light on the area's prehistory.

The remains of a 17-year-old woman who died about 7200 years ago were found buried in a cave on Sulawesi. Adam Brumm at Griffith University in Australia and his team sent one bone for DNA extraction.

The woman's DNA was most similar to that of modern Aboriginal Australians and Papuans (*Nature*, doi.org/gsnv). The simplest explanation is that she is descended from the first wave of modern humans who entered the South-East Asian islands from the

mainland more than 50,000 years ago. Some of those people travelled onwards to Papua New Guinea or Australia, but others settled in places like Sulawesi.

About 2.2 per cent of the woman's DNA came from the Denisovans, a human group known from a handful of sites in Asia who interbred with modern humans. "It's now possible that Sulawesi could be where our species encountered and interbred with the Denisovans," says Brumm. This has been suggested before, as Denisovan DNA is particularly common in people from Papua New Guinea and the Philippines. **Michael Marshall**

Zoology

Caterpillars hit by light pollution

AREAS with LED street lights have up to 50 per cent fewer moth caterpillars living nearby, which could affect the area's ecosystem.

Douglas Boyes at the UK Centre for Ecology & Hydrology and his colleagues used Google Maps and Google Street View to identify parts of three counties in England where there were pairs of habitat areas that appeared identical, except that one had street lights while the other didn't.

They then counted the number of moth caterpillars in each 14-metre-long habitat, finding about eight species. The team also noted the type of street light – whether it was an LED light or an older, yellow, sodium lamp – and the intensity of light it produced.

Sites where street lighting was present had 47 per cent fewer caterpillars in hedgerows and 33 per cent fewer caterpillars in grass margins. LED lights had a bigger effect than sodium lamps (*Science Advances*, doi.org/gsqp).

"What is really clear from the discussion is how much the different types of light are having an impact, with LEDs seeming to be worse for caterpillars," says Heather Campbell at Harper Adams University in the UK. **Chris Stokel-Walker**



To hear a smile

Having spent most of her life serving locals from behind a bar, Barbara was never short of people to talk to. But these days are quieter than they used to be.

That's why our befriending service couldn't be more important right now. Giving back to our older customers, in need of a little company, with a friendly voice to talk to. For Barbara, that's Gary.

Through their weekly chat, the pair soon realised just how much they had in common, and what began as a quick call has become a lasting friendship.

And theirs is just one of thousands of conversations we'll have in the next year. Small moments which provide the belief we can help tackle loneliness.



sky
believe in better

The columnist

Annalee Newitz
on ancient money's
links to the future **p18**

Letters

Sucking carbon
from the air may
be just the ticket **p20**

Culture

Stories from the
International
Space Station **p24**

Culture columnist

Michael Marshall
finds novel *The Actual*
Star a delight **p26**

Aperture

The pick of the pics
from our inaugural
photo contest **p28**

Comment

Better alternatives

The UK is considering opening a brand new coal mine. Here's why it doesn't need one, says **Mark Peplow**

THE past few months have seen temperature records smashed. Global warming has cranked up extreme weather events that have wrecked towns by fire and flood. So it seems an odd time for the UK to consider opening a new coal mine.

Woodhouse Colliery, near Whitehaven in Cumbria, would be the first new deep coal mine in the UK for decades. Although the county council approved the project in principle in 2019, the UK government vacillated over the decision and then announced a public inquiry, which is due to start on 7 September. As the UK prepares to host the COP26 climate summit in November, many argue that Woodhouse Colliery is incompatible with the UK's climate goals.

The colliery's coal wouldn't fuel polluting power stations. Instead, the mine would supply "coking coal" to the steel industry in the UK and Europe. Coke is a dense form of carbon that plays three vital roles in steel-making. Inside a blast furnace, carbon chemically removes oxygen from iron oxide ore to create crude iron. Burning coke also raises the temperature to 2000°C or more, allowing molten iron to be tapped from the bottom of the furnace. Finally, a dash of carbon in the iron strengthens the metal, helping it to become steel inside a second furnace.

Coke-based steel-making generates billions of tonnes of carbon dioxide every year and accounts for 7 to 9 per cent



of all human-made CO₂ emissions. But advocates for the mine say that a domestic supply of coke could help UK steel-makers curb their emissions because it would avoid the CO₂ released by transporting steel-making coal from abroad. In March, West Cumbria Mining, the company behind the colliery proposal, said: "Until an alternative for coking coal is found, such coal production is essential."

But alternatives already exist. More than 100 commercial plants around the world can use natural gas to convert iron ore into iron. By feeding that iron into an

electric arc furnace to make steel, the whole process emits about 35 per cent less CO₂ than the conventional blast furnace route.

Replacing the natural gas with hydrogen potentially offers even greater carbon savings. When hydrogen reacts with iron ore, it produces iron and water. A Swedish project called HYBRIT is taking this approach to make "green steel" with about 5 per cent of the carbon footprint of conventional steel. It uses wind-powered electrolyzers to split water into hydrogen and oxygen, and uses more renewable electricity to run its furnaces.

HYBRIT is no blue-skies laboratory project. It is a partnership between some of Sweden's biggest companies – steel-maker SSAB, mining firm LKAB and power company Vattenfall – which is already operating a pilot plant capable of producing about 1 tonne of iron per hour. A larger plant is in the works and HYBRIT aims to have green steel on the market in 2026.

Green steel is currently more expensive than conventional steel. But renewable energy is getting cheaper by the day and the cost of producing hydrogen with electrolyzers is falling fast. Meanwhile, the European Union is considering a border tariff that would impose costs on importing carbon-intensive goods like steel. Democratic law-makers in the US proposed a similar border tax in July. These measures would squeeze conventional steel-making, potentially helping low-carbon methods to gain a commercial advantage.

Opening up a new source of coking coal in the UK is a step in the wrong direction. The UK government and industry should instead work together to invest in burgeoning low-carbon steel-making technologies that will play an essential part in tackling climate change. ■



Mark Peplow is a science journalist based in Penrith, UK

This changes everything

What ancient money tells us about the future The way that some of the first coins were viewed 2500 years ago is similar to how we regard computers today, writes **Annalee Newitz**



Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading

Architect Marwa al-Sabouni's *Building for Hope*, a fascinating look at the meaning of home in cities across the world.

What I'm watching

Reservation Dogs, a comedy on FX on Hulu about Native American kids in Oklahoma who just want to eat spicy chips and escape to California.

What I'm working on

Researching various tests for AI "intelligence" for an episode of my podcast, *Our Opinions Are Correct*.

This column appears monthly. Up next week: James Wong

WHAT may well be the oldest metal coins in the world have been identified by archaeologists at an ancient abandoned city known as Guanzhuang in China. Made of a bronze alloy, the coins were discovered in a well-preserved mint – complete with moulds and other tools – and carbon-dated to between 550 and 640 BC.

Like many Bronze Age coins from the region, they were cast in the shape of 14-centimetre-long spades, their stylised shovel blades attached to carefully crafted hollow handles. These ancient coins existed during a transitional period between barter and money, when coins were a novel concept, but everybody knew that agricultural tools were valuable.

Reading about this incredible discovery in the journal *Antiquity*, I kept thinking about the way modern people represent computer networks by describing machines as having "addresses", like a house. We also talk about one computer using a "port" to send information to another computer, as if the data were a wee boat floating on the sea of electrons to reach its destination. It's as if we are in the Bronze Age of information technology, grasping desperately for real-world analogies that will help us grasp a concept that has barely begun to transform our civilisations.

Think of spade coins as the economic equivalent of computers that have "windows" and "folders" and all kinds of other silly things from the physical world that have nothing to do with what the computer is actually doing. Now consider what happened to the spade coin. Over centuries, metalworkers made these pieces of bronze into more abstract shapes. Some became almost humanoid

figures, the shovel converted into two flat, rectangular legs topped by a square head. Other spades morphed into vaguely crescent shapes, their handles reduced to small half-circles. Eventually, most ancient coins in China had boreholes in the "handles", perhaps so that people could carry them on a loop of twine.

As spade coins grew more abstract, people inscribed them with number values, the names of clans who issued them and the locations where they were forged. They became more like modern coins, flat and covered in writing. Looking at one of these later

"If climate change leads to a return to semi-nomadic life, our mobile devices might resemble boats not phones"

pieces, forged almost 800 years after the artisans of Guanzhuang crafted the first coins with clay moulds, you would have no idea that they were once intended to look like a spade. Money, in other words, had a historical arc. At the dawn of monetary systems and economics, it wasn't an abstract thing. Centuries passed before those spades became blobs of data for measuring value.

This makes me wonder when we will stop needing to describe computer networks by referring to addresses and ports. Will we ever stop talking about files, folders and trash cans on our desktops? Or will we develop an entirely new set of symbols that allow us to interact with our digital information more smoothly?

Taking spade coins as our guide, we can speculate that far-future computer networks will no longer contain any recognisable

references to houses and water transit. But they still might conjure up some of the ideas we associate with home. In fact, computer networks – if they still exist at all – are likely to be almost indistinguishable from our houses and cities, their sensors woven into walls and roads. Our network addresses might actually be the same as our street addresses. If climate change leads to floods, mass migrations and a return to semi-nomadic life, our mobile devices might look more like boats than phones. Docking at a port really will require us to have the proper data protocols as well as the right kind of anchor.

My point is that the metaphors of the information age aren't random. We have adopted terms like "home screen" because our glassy slabs of data sometimes do offer the comfort of an easy chair after a long day at work. In some sense, we aspire to settle on the shores of data lakes – and to defend our intangible property with weaponised memes shot through optical fibres beneath the sea. Ultimately, this desire could change the way we understand home, as well as how we build computers.

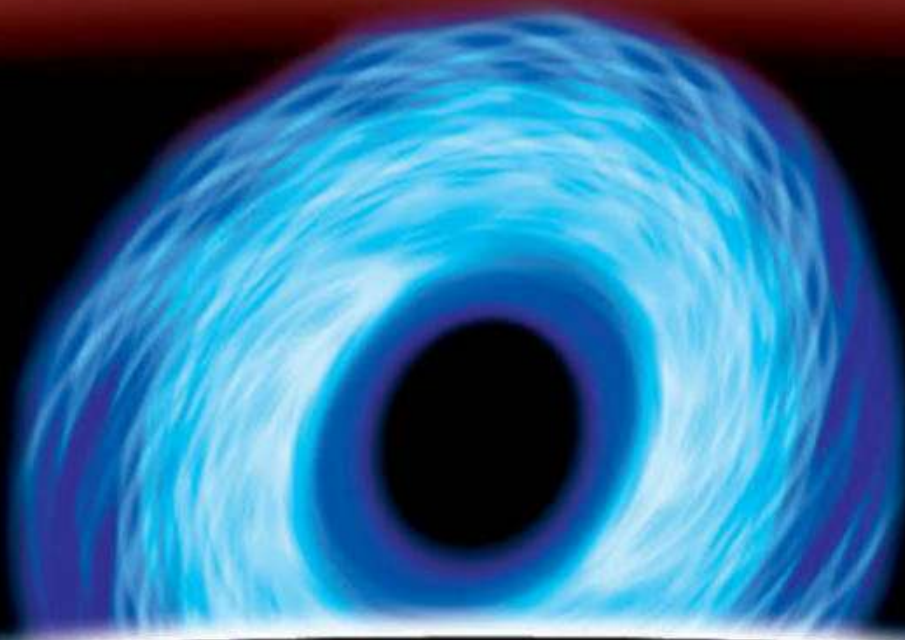
Imagine trying to explain the stock market and cryptocurrency to one of those Guanzhuang bronze workers, forging spade coins back in the 7th century BC. We would share an understanding of money and value, and we would recognise the importance of spades. But we have about 20 layers of abstraction piled on top of that original, much-needed spade. So as we cast our minds forward, we have to think about what new abstractions will adhere to our information technology. Perhaps the one thing we can count on is that humans will still appreciate the comforts of home. ■

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Editor's pick

Sucking carbon from the air may be just the ticket

21 August, p 41

From Pete Drake,
Penmon, Anglesey, UK

There is a general view that the cost of saving the planet using machines to suck carbon out of the air, known as direct air capture (DAC) technology, will be prohibitive.

But consider these figures. A London to New York flight is about 5500 kilometres, producing about 91 tonnes of carbon dioxide and carrying about 500 people. As you report, some developers of DAC say it could cost less than £200 per tonne of CO₂ captured in the 2020s.

A tax on flying to cover the carbon capture would cost £36 per passenger in this case. I wouldn't hesitate to pay that if it saves my children's future.

On Australia's battle with the covid-19 delta variant

21 August, p 7

From Steve Johns,

Axedale, Victoria, Australia

Alice Klein's article says the outbreak of covid-19 in Australia is blamed on the delta variant. Yes, the variant is more transmissible, but the reason we have the outbreak is partly political.

Some right-wing politicians are opposed to lockdowns and the outbreak in Sydney wasn't and still isn't being contained because "lockdowns" weren't and aren't being implemented in locations until the virus is seen to be spreading there.

Why are we still waiting for other covid-19 vaccines?

14 August, p 8

From Terry Threlfall, London, UK

Your latest round-up of covid-19 vaccines was useful and thorough, and more detailed than most accounts. You mentioned other vaccines that the UK government has supported, but which haven't

yet come to fruition – those from CureVac, Valneva and Novavax.

This got me wondering why these and others still aren't launched.

Are they being delayed for commercial reasons or in the hope they can be tweaked to give them an advantage over existing shots? And what about the factories in Scotland and north-east England earmarked for their production? Are they lying idle, when they could be used to produce vaccines for the world?

Let's hope vested interests don't spoil the revolution

14 August, p 46

From Brian Glassup,

Llanfairfechan, Conwy, UK

Graham Lawton's article on making dairy products using microbes describes technology that can bring significant and welcome benefits: greatly reducing emissions of greenhouse gases, improving animal welfare, helping to better human health and nutrition, and so on.

While he says lobbying against these products hasn't yet begun, it is only a matter of time before vested interests push back. Just as renewable energy initiatives are resisted by fossil fuel businesses and nations whose wealth derives from fossil fuels, I expect livestock businesses and nations whose economy is based on livestock farming to follow the same path.

Making fast work of Olympic records

14 August, p 25

From Sam Edge,

Ringwood, Hampshire, UK

Laura Healey's explanation of possible reasons for the large number of records broken on the athletics track at the Tokyo

Olympics was interesting.

It suggests to me that track and field athletes should be required to be barefoot, bareheaded – other than religious headgear – ungloved and wearing only simple, loose-fitting clothing. What's more, tracks, other surfaces and equipment for events should be constructed to agreed neutral specifications.

If it is cheating to use performance-enhancing chemicals, surely it is also cheating to use performance-enhancing shoes? If not, why not allow high jumpers to wear springy stilts and gene therapy to increase athletes' muscle mass?

Without wanting to take away from any athlete's achievement, if they broke a world record not because they are inherently better but because they had better footwear, then has the record actually been beaten? Instead, one has been set for a passively assisted version of the event.

Offices could well become more sterile places to work

14 August, p 36

From Colin Gray, Gateshead, UK

I read with interest Annie Murphy Paul's article on the impact of the physical working environment on productivity, which was very much focused on the office.

With office work very likely to be different when we enter the post-pandemic period, I was intrigued about the potential impacts on productivity.

It may be that offices become underpopulated as flexible working becomes the norm, office desks become more widely spaced and businesses change from a first-come, first-served "hot desk" policy to a "clear desk" policy that promotes uncluttered desk

spaces that enable hygienic, easy-to-clean surfaces.

That would result in a reduction in the personal photos and mementos that provide ownership of our workspaces, as well as the likelihood of unplanned colleague interactions. This could lead to a loss of any empowered feelings within our workplaces, which are described in the article as being beneficial to productivity.

For a real taste of space, we should go a little further

31 July, p 16

From Jody Wear,

New Minas, Nova Scotia, Canada

Because of space tourism, there has been much talk lately of what constitutes being in outer space. Many definitions are strictly technical and scientific in nature. Perhaps a more philosophical position should be considered.

Let us apply the distinction between object and subject – that is, when would you feel you are in outer space? I suggest that at about 12,742 kilometres (one Earth diameter) away, the planet would be truly other and set off nicely against the background of space. I can't, however, afford to test my hypothesis.

What is 20 years when you're building a citadel?

14 August, p 23

From Bryn Glover, Kirkby

Malzeard, North Yorkshire, UK

You report that Machu Picchu has been declared 20 years older than we thought. Considering it was built on top of a mountain with no builders' merchants and no power tools, it probably took well over 20 years to complete. This variability in its age seems like no big deal. ■

For the record

■ The nearshore trawling ban mentioned in our report on kelp conservation off southern England (31 July, p 18) has no definite expiry date.



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Graham Lawton

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Helen Thomson

New Scientist consultant editor, author of *This Book Could Fix Your Life: The science of self help and Unthinkable: What the world's most extraordinary brains can teach us about our own*

HOSTED BY

Tiffany O'Callaghan

New Scientist head of features



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The gene therapy revolution in healthcare

Gene therapies offer hope to people with rare disorders. But to maximise its benefits, our healthcare systems need to change how they assess, deliver and pay for treatments

Gene therapy offers millions of people with life-threatening rare diseases the potential for longer, healthier lives. But while the therapeutic technology has advanced, our healthcare systems, and the regulatory frameworks in which they operate, have not.

The issue is that gene therapy is utterly unlike the conventional treatments healthcare systems are set up to provide. For a start, a single treatment can provide life-long benefits – unlike conventional treatments for chronic diseases, which must often be taken for life. Gene therapies are also designed to treat conditions that are difficult to diagnose; so by the time the disease is known, sometimes it has already irreversibly progressed. And many healthcare systems are not set up to pay for gene therapy.

This raises important questions about how to handle gene therapy. The central question is how to determine the value of gene therapy not just for the patient, but for their families and for broader society. Another is how our healthcare infrastructure should adapt to best capitalise on this therapy. Alongside this is the challenge of finding innovative ways to fund the treatments.

These questions were the focus of a recent New Scientist Debate on *The Gene Therapy Revolution in Healthcare*, sponsored by Novartis Gene Therapies. The debate brought together a panel of experts to discuss the changes required to take advantage of the benefits that gene therapy offers.

Gene therapy is a treatment for diseases caused by a faulty or absent gene. It works by replacing the gene with a working copy that halts the progression of the disease. That's why a single one-time treatment can have life-long benefits. "Cell and gene and other transformative therapies are very promising," said MEP Ondřej Knotek, co-chair of the TRANSFORM MEP

Interest Group that aims to promote dialogue on transformative therapies.

The first challenge in harnessing gene therapy is early diagnosis. The symptoms of genetic disorders often emerge in early childhood and can progress swiftly. So there is often only a narrow window of opportunity for gene therapy. "The earlier you treat these patients, the better the benefit of the product," said Mike Fraser, general manager of Europe, Middle East and Africa at Novartis Gene Therapies.

One way to achieve earlier diagnosis is with newborn screening. But many countries do not test for a wide range of rare diseases. "Without better newborn screening, the

treatments aren't going to reach the patients in time," said Georgina Morton, chair of the ArchAngel MLD Trust, a charity that helps patients and their families face rare diseases such as metachromatic leukodystrophy (MLD), and which also promotes rare disease screening for newborn babies.

At present, she says that the majority of patients treated are identified because they are younger siblings of patients whose disease is sadly too advanced to be helped. Morton would like to see a committee in the UK dedicated to newborn screening.

The question of cost-effectiveness is particularly charged for gene therapy. Some treatments may present a perceived high



NOVARTIS GENE THERAPIES

The expert panel for the *New Scientist* debate (clockwise from top left):

Georgina Morton
The ArchAngel MLD Trust

Paolo Morgese
The Alliance for Regenerative Medicine

Ondřej Knotek
Member of the European Parliament

Mike Fraser
Novartis Gene Therapies



cost, but do the scale and duration of benefits still represent value for money? How should society decide?

A key factor is the timescale of benefit. The expectation is that gene therapy will benefit the patient for years or even their whole lifetime, said Paolo Morgese, an expert on innovative healthcare technologies at the Alliance for Regenerative Medicine, an international advocacy organisation dedicated to realising the promise of regenerative medicine.

Conventional treatments have much shorter-lived effects and require repeated treatment over a patient's life-time, compared to gene therapy, which requires one single-dose.

Then there is the scale of these benefits. Conventional therapies can help a patient live longer and have a better quality of life, but that individual might still be unable to work and might still spend much time in hospital.

By contrast, gene therapy can offer life-long benefits (see box). "That person could become a working person within the community," said Fraser. "There are huge values to society in these one-time gene therapies."

An important challenge is to find innovative ways to pay for these new treatments. Knotek said one possibility is a managed entry agreement, which spreads the cost over time. A related option is to use a pay-for-performance approach. In this case, the healthcare system pays in instalments but only for as long as the patient benefits. If the benefits stop, so do the payments. That means a patient's health must be tracked for years or decades, which is itself a challenge.

"There's an element of risk-sharing that we're all going to have to be comfortable with," said Fraser.

Finally, Knotek said the European Union could set up a central fund to pay for treatments. Since these therapies are not available in all countries, patients will have to travel abroad for therapy. "We must have this possibility for the patients to get [gene therapies] from the states where it is available," he said.

International cooperation in healthcare has not been attempted on this scale, but given the promise of gene therapy, it is likely to offer a significant step forward.

For more information about gene therapy visit: www.novartis.com/cellandgene

HOW GENETHERAPY CHANGES LIVES

The difference between children who receive gene therapy and children who do not is like "night and day", said Georgina Morton, who has a unique perspective on the impact these patients have on the healthcare systems. Her daughter was diagnosed with metachromatic leukodystrophy (MLD), a rare genetic disorder in which certain fats destroy the protective myelin sheaths around neurons.

"An untreated child on average would have between 10 and 100 visits to a healthcare practitioner in a 12-month period," she said. "They will have had 3 or 4 hospital stays as an inpatient at 15 to 20 nights per time. They'll be on 8 to 10 medications round the clock, day in day out. They'll have 24-hour care."

The impact on families can also be huge. "[Children with rare diseases can] have two parents who've gone from having a mortgage and two healthy professional incomes to relying on state benefits," she said.

Worse, conventional treatments are ultimately unable to save the child. "I've witnessed children with MLD who have rapidly lost their ability to walk, to talk, to swallow, to hear," said Morton. "They've become incontinent, developed dementia, seizures, and after all of this immeasurable suffering they've passed away, the majority before the age of 5."

In contrast, Morton knows children who have had gene therapy for MLD – often the younger siblings of those who died – who are now 10 years post-treatment. They are "attending school, winning medals for sport, designing computer programs, making YouTube videos, no hospital visits, no medications," she said. In many cases their teachers and friends have no idea they were ever ill.

Cost should not be the main issue, she says, pointing to other treatments that are similarly expensive. "When we first heard about heart transplants and breakthroughs in oncology and bone marrow transplants, no one was saying 'we can't afford to do a heart transplant', 'we can't afford to do bone marrow transplants'," she said. "These treatments shouldn't be luxuries."

"The first challenge in harnessing gene therapy is early diagnosis"

A team effort

The International Space Station is a marvel to behold and a new documentary speaks to those who have lived on board, finds **Abigail Beall**



Film **The Wonderful: Stories from the space station**

Clare Lewins
Universal

OVER 20 years ago, five space agencies representing 15 countries came together to build one of the most ambitious engineering projects the world had ever seen. It took more than 30 missions, with parts manufactured thousands of kilometres apart and assembled by spacewalkers orbiting at 28,000 kilometres per hour, before the International Space Station (ISS) was completed in November 2000.

But *The Wonderful* – a documentary celebrating the ISS – isn't an engineering story. It is the story of the people who have made the space station their home in the decades since it was first occupied, and the story of their loved ones back on Earth. Since it was first

occupied, there has never been a day when there wasn't someone living on the ISS.

From the crew who assembled the space station to its most recent inhabitants, this documentary explores the lives of those who have been involved in the ISS since the beginning. Punctuated with music and recordings of Earth from space, the night sky or training facilities, *The Wonderful* tells the story of the ISS through those who have been most involved with it.

Many of those interviewed dreamed of going into space since childhood, when looking at the night sky sparked their imagination, but it wasn't always plain sailing. When Ginger Kerrick's dreams of becoming an astronaut were dashed after NASA discovered she had kidney stones, she instead trained astronauts to prepare for their missions and supported the first crew to fly on the space station – she was there with them until take-off.

Astronaut Peggy Whitson spent 10 years applying to become an astronaut until she was finally selected. She went on to spend 665 days in space in her career – more than any other NASA astronaut.

Some didn't share this childhood dream. Sergey Volkov describes how growing up with his father, the cosmonaut Aleksandr Volkov, made him think going into space was "heroic and difficult".

"In all the years since it launched, there has never been a day when there wasn't someone living on the ISS"

Many years later, Aleksandr was surprised to learn of his son joining the Russian space agency, Roscosmos, through reading the case files of those selected for the physical assessment.

Pictures and videos can help us understand what it is like to be in space, but nothing quite

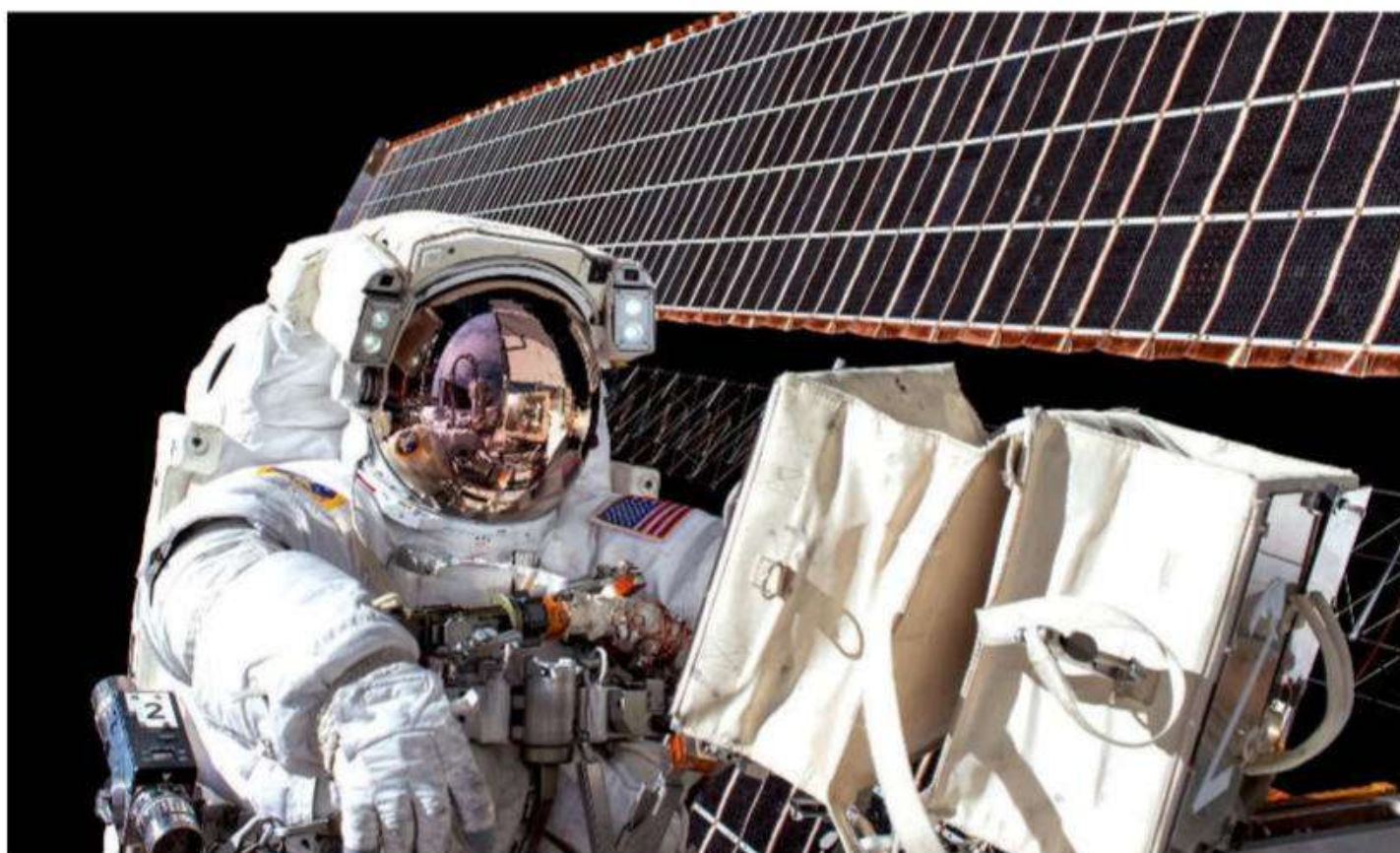
encapsulates the full experience like hearing it first-hand. In *The Wonderful*, it is the added details that bring life on the ISS to life. Scott Kelly remarks on the vibrant colours he could see when his vision wasn't altered by the air, Tim Peake describes the sensation of silence slowly creeping up on him when he made his way into the vacuum of space for his spacewalk, and Samantha Cristoforetti describes seeing the space station up close for the first time.

Behind every astronaut living 400 kilometres above Earth's surface, there are people on the ground missing them. *The Wonderful* gives us a glimpse of what it is like when your loved ones are floating above your head. NASA astronaut Cady Coleman's husband, Josh Simpson, describes hearing from his wife every night, before going outside with their son Jamey to look up and see the ISS whizzing by overhead.

While everyone's experience of space is different, something that seems to bring those who have been there together is a realisation of how fragile the planet is. A few people in the film mention their surprise at the size of the atmosphere compared with the planet, which Kelly describes as like a contact lens on someone's eye.

While climate change isn't explicitly mentioned, it is difficult not to make a comparison between the feat of science and engineering being celebrated in *The Wonderful* and the challenge facing Earth today. But the story of success that is the space station leaves the viewer with hope that, when working together, humans can do great things. ■

Astronaut Scott Kelly performing a spacewalk during his time on the ISS



NASA

Scientifically telling

How our brains respond to different stories makes for fascinating reading, finds **Simon Ings**



Book

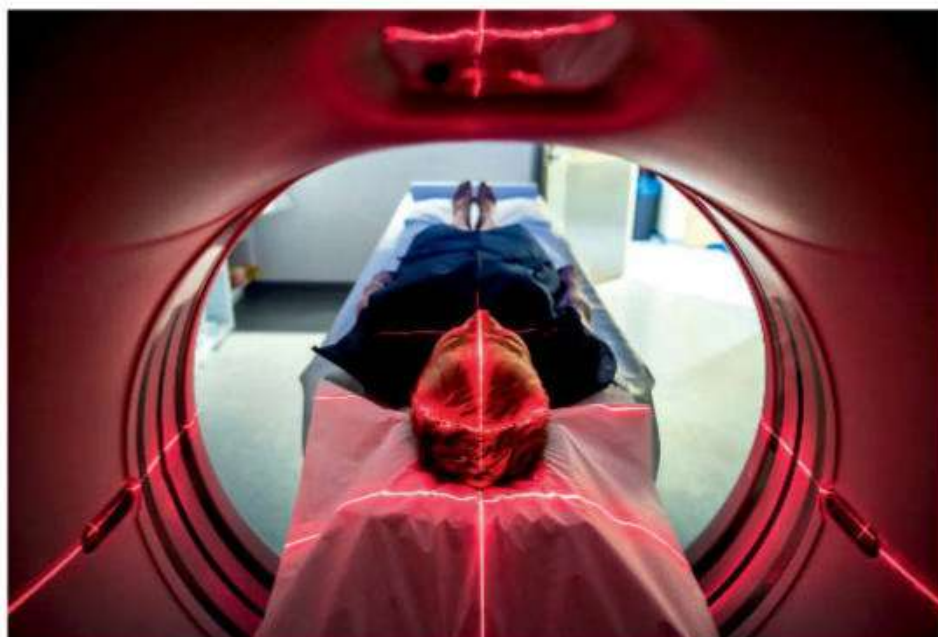
Wonderworks: Literary invention and the science of stories

Angus Fletcher
Swift Press

NEUROLOGICAL takes on art are fertile ground for a book. In 1999, neurobiologist Semir Zeki published *Inner Vision*, which explained how different schools of art affect us neurologically – put crudely, Rembrandt tickles one corner of the brain, Mondrian another. Eight years later, Oliver Sacks contributed to an already crowded music psychology shelf with *Musicophilia*, a collection of true tales in which neurological injuries and diseases are successfully treated with music.

Angus Fletcher believes the time has come for literature to get the neurological treatment too. Over the past decade, researchers have used pulse monitors, eye-trackers, brain scanners and other gadgets to look inside our heads as we consume novels, poems, films and comic books. Now these efforts are starting to bear fruit, as he sets out in *Wonderworks*.

Fletcher's own experimental work includes a 2016 study into the psychological effects of "free indirect discourse", a form of narrative that draws attention away from the narrator, instead slipping in and out of characters' experiences and consciousness. Five literary texts that deal with revenge, including Homer's *Odyssey* and Mario Puzo's *The Godfather*, were presented in an adapted form to volunteer readers, sometimes as "straight" stories and at other times written in free indirect discourse. The study found that readers of the latter tales not only offered more empathic responses to a follow-up questionnaire, they also



JOHNNY GREIG/GETTY IMAGES

MRI scans and other tools allow researchers to see our neurological responses to art

showed a greater understanding of behaviours and moral choices they didn't identify with.

The claim that reading novels improves theory of mind – the ability to put yourself in someone else's shoes – has been circulating since the mid-2000s, and has been especially popularised by a team of psychologists at the University of Toronto headed by Keith Oatley. When we are very young, we assume that everyone thinks and feels as we do, but somewhere around our fourth birthday, most of us begin to realise that other people's heads have their own distinct contents.

Our theory of mind develops as we imaginatively simulate other people's thoughts. Since stories can present characters' interiority, might this aid us as we practise and improve our real-life theory-of-mind skills? Research by Oatley and his colleagues has pointed in this direction. Other studies suggest that fiction readers are more social, that romance fiction can make us more empathetic and that fiction can increase the empathy of low-empathy individuals.

Defining technology as "any human-made thing that helps to solve a problem", Fletcher now jumps several stages further, hypothesising that a story is a suite of narrative-emotional technologies that have helped our ancestors cope with the psychological challenges posed by human biology.

Wonderworks, then, is Fletcher's scientific history of literature – each of its 25 chapters identifies a narrative "tool" that triggers a traceable, evidenced neurological outcome. Every tool comes with a goofy label: here you will encounter Butterfly Immersers (which push our sense of socially acceptable behaviour, calming the activity of the brain's medial frontal gyrus) and Stress Transformers (which play on the shared neurological origins of horror and humour).

The book is an intelligent, engaged and erudite attempt to neurologically tackle not just some abstract and simplified "story", but some of the world's greatest narratives, from the *Iliad* to *Dream of the Red Chamber*, from Disney's *Up* to the novels of Elena Ferrante. It speaks to the inner reader in us all, as well as to the inner neurologist. ■

Simon Ings is a writer based in London

Don't miss



Watch

How to Feed the World Without Costing the Earth by the Science Museum in London will see an expert panel, including chef Heston Blumenthal, consider how we should produce, transport and consume food. Watch online at 7.30pm on 8 September.



Read

Your Wit Is My Command is Dublin-based computer scientist Tony Veale's road map for building machines that can appreciate humour and even invent their own puns, sarcastic remarks and jokes.



Watch

Ars Electronica 2021 is a gigantic helping of science, art, new media and smart thinking from around the globe. This year's festival examines the future of our digital world. Streaming live from 8 September.

The sci-fi column

A multi-timelined epic Monica Byrne's fantastic second novel follows three storylines in the past, present and future, all of which are linked by historical threads and religious ideas, says **Michael Marshall**



Michael Marshall is a science writer based in Devon, UK, and author of *The Genesis Quest*. Science fiction shaped his brain. @m_c_marshall



MAURITIUS IMAGES GMBH/ALAMY

The Actual Star culminates in Actun Tunichil Muknal in Belize

In response to devastating sea level rise and extreme weather, humanity has adopted a nomadic existence. Nobody is allowed to stay in the same place for more than a few days.

Acquiring possessions beyond what is absolutely necessary is condemned as “hoarding”: these future people look back on our consumer era with horror. Byrne imagines a swathe of new social rules, an entire political system based on decentralised technologies like blockchain and, crucially, a new religion.

It is in the religion that the three timelines link. Byrne's futuristic theology is based on Mayan beliefs, specifically the idea of Xibalba: an underworld ruled by gods of death.

But this version of Xibalba is a place where people can finally perceive the world as it truly is, without the filters and concepts imposed by our sense organs and brains – to comprehend “the thing-in-itself”, as the philosopher Immanuel Kant put it. Or as Ixul thinks at one point: “The star we see is not the actual star.” In all three timelines, characters converge on the cave of Actun Tunichil Muknal in Belize where this transcendent perception may be possible.

If this all sounds like a lot, it is, but the book is perfectly paced: it is leisurely enough to let you get to know the people and grasp the heady concepts, but there is constant forward momentum and a steady crescendo. The climax is as dramatic as anyone could wish for, but for me the real joys of *The Actual Star* are the vivid characters and societies. It is a book that will resonate with me for a long time. ■



Book
The Actual Star:
A novel
Monica Byrne
Harper Voyager

Michael also recommends...

Film
Nomadland
A more contemporary take on nomadic life, Chloé Zhao's beautiful film follows Frances McDormand's Fern around the US in search of work following the 2008 economic crisis.

TV
Loki
Disney+
The latest Marvel series is a riot of invention that fuses time travel, multiple universes and a cosmic bureaucracy – even if the finale is a bit of a let-down.

WITH her second novel, author Monica Byrne has pulled out all the stops. *The Actual Star* was eight years in the making. It has three storylines, separated by millennia: one is set 1000 years ago in a declining Mayan kingdom, one in 2012 and one in a distant future shaped by catastrophic climate change. The seemingly disparate stories are rapidly revealed to be linked.

When a book is this ambitious, either it is a thumping success or it falls on its face. Happily, *The Actual Star* is a stone-cold masterpiece. It is one of the most moving novels I have read and surely a contender for major awards.

The first thing that struck me was how immediately immersive the three stories are. The ancient Mayan storyline follows three young members of a royal family: Ajul, Ixul (the “x” is pronounced “sh”) and Ket. Byrne keeps the story tightly focused on their perspectives. She has a tricky tightrope to walk because the characters use human sacrifice to solidify their political power, and Ajul and Ixul have incestuous sex.

Yet Byrne shows their motivations and makes them sympathetic, without unduly softening them.

The middle timeline follows a young woman named Leah from Minnesota, who travels to Belize on a journey of self-discovery: her late father was from there, but she never met him and is in search of her identity and heritage. Byrne

“The Actual Star is a stone-cold masterpiece. It's one of the most moving novels I have read”

finds great depth and nuance in this story, never falling into the trap of exoticising the Belizean culture. It helps that some chapters are told from the perspectives of two Belizean tour guides, Xander and Javier, so we get to see Leah through their eyes.

The futuristic sections follow Niloux deCayo, who finds herself labelled a heretic when she dares to challenge her society's beliefs. Byrne's version of the future is richly imagined.

**New
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Awards 2021**

HAVE YOUR SAY!



Our guest judges were



Sue Flood

Sue Flood is an award-winning photographer and filmmaker, zoologist, adventure travel leader, public speaker and Fellow of the Royal Photographic Society.



Chris Packham

Chris Packham is an award-winning naturalist, television presenter, writer, photographer, conservationist, campaigner and filmmaker.

Plus

Helen Benians

New Scientist Picture Editor

Timothy Revell

New Scientist Comment and Culture Editor

Penny Sarchet

New Scientist New Editor

Award categories

- 1. The natural world**
- 2. Our changing environment**
- 3. Modern life**

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SHORTLIST AND CATEGORY WINNERS ANNOUNCED

The awards celebrated images that illustrate how science and technology affect our lives and the world around us. Take a look at the incredible images and have your chance to vote for the overall winner now.

To find out more visit
newscientist.com/publicvote

PHOTO LEFT: DAMIANKUZDAK/ISTOCK

Category: **Our Changing Environment**



**CATEGORY
WINNER**

Photographer
Nick Lancaster

These young kestrels were inhabiting an iron pipe on a small industrial estate in North Yorkshire, UK, and were just days from fledging when Nick Lancaster took this photo. "I love the rusty colours and the way that is complemented by the birds' own rusty colours," says Chris Packham.



SHORTLIST

Photographer
Jack Pokoj

Even though it is illegal to use certain fishing nets over coral reefs in the Philippines, unfortunately they sometimes still end up there. This image shows a range of corals, sponges and feather stars, as well as fishing equipment.



Award winners



THESE fascinating images depict how science and technology influence our lives and the world around us, from the stunning wildlife inhabiting even the most unassuming of places to the environmental and biological hazards that are transforming our planet. The selected photos over the next few pages are the shortlisted and winning entries to our new competition, the *New Scientist* Photography Awards.

Winners and runners-up for the three categories – The Natural World, Modern Life and Our Changing Environment – were chosen by wildlife presenter Chris Packham, award-winning photographer Sue Flood and *New Scientist* editors Helen Benians, Timothy Revell and Penny Sarchet.

Each judge was impressed by the competition's overall standard and quality. Some entries had great ideas behind them and were "strikingly beautiful", says Packham. "I think in each category, there were two or three images that really jumped out," says Flood.

While the first and second-place entries for each category have already been decided by the panel, the overall winner will be judged by public vote. You can choose your favourite image at [newscientist.com/publicvote](https://www.newscientist.com/publicvote), before the winner is declared in October. Voting closes on 26 September. ■

Gege Li



RUNNER-UP

Photographer
Nigel Ferris

Taken using a drone, this image shows a corn circle in Wiltshire, UK. It depicts a symbol used to indicate a biohazard, acting as a comment on the effect we have on the planet.



SHORTLIST

Photographer
Alexander Turner

This photo was taken on a rooftop in central London and is part of a photo essay that explores the impact of beekeeping on native pollinators.

Category: Modern Life



CATEGORY WINNER

Photographer
Kieran Doherty
In this image, Kieran Doherty's father Hugh is celebrating his 82nd birthday during the covid-19 pandemic. Three of his grandchildren are stood outside and are singing *Happy Birthday*. "I felt this was a very moving image," says Sue Flood.



◀ **RUNNER-UP**

Photographer

Kate MacRae

During the UK lockdown in May 2020, Kate MacRae developed a strong relationship with "Colin" the robin.

◀◀ **SHORTLIST**

Photographer

Rachel Piper

This gull spotted a tasty treat on a summer's day in a coastal town in Yorkshire, UK. The man was oblivious, but escaped unscathed.



SHORTLIST

Photographer

Emma Friedlander-Collins

These plants were collected from the edge of a building site in Sussex, UK, and then scanned using a printer to show them in a unique way.

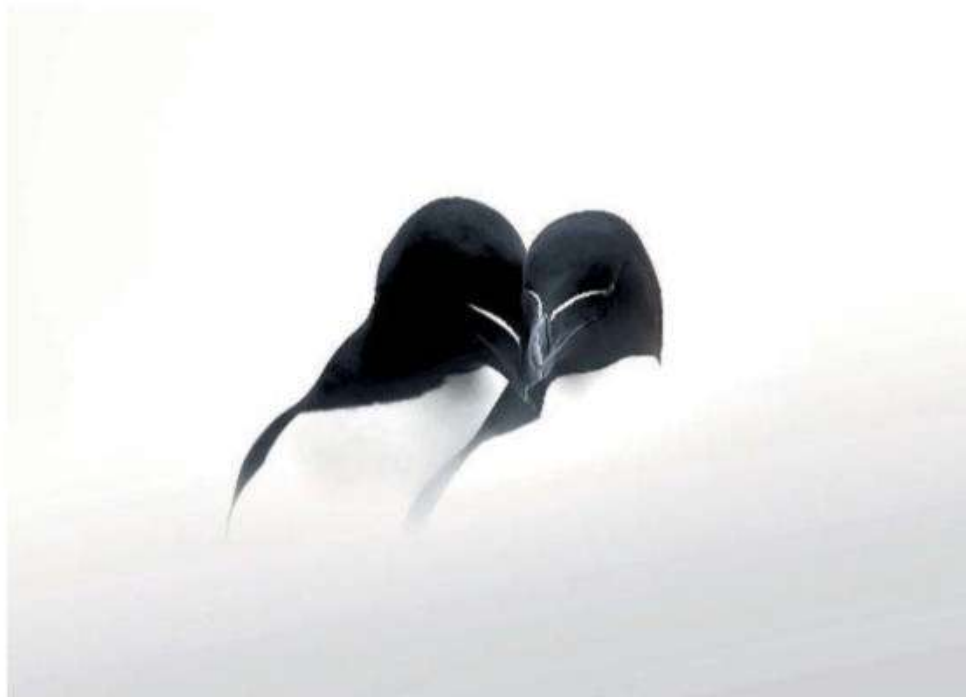
Category: **The Natural World**



▲ **CATEGORY
WINNER**

Photographer
Barry Webb

Made of 19 photos combined together, this image shows a common rough woodlouse stretching up to feed on a gelatinous slime mould in the south of Buckinghamshire, UK. "It is absolutely the one I wish I'd taken," says Sue Flood.



◀ **RUNNER-UP**

Photographer
Rachel Bigsby

Razorbills pair for life, and these two are huddling together on Skomer Island off the coast of Pembrokeshire, UK. The shot was taken during a spell of heavy sea fog that hung around on the island for days.

SHORTLIST ►

Photographer

Martin Brazill

Munching on a

Hemerocallis

"Frans Hals" day lily,

this hoverfly was

photographed in

Suffolk, UK, earlier

this year. It is using

its proboscis to get

to the pollen.



◀ SHORTLIST

Photographer

Georgie Bull

This blenny was found

in Chesil Cove on the

Isle of Portland in

Dorset, UK. It seemed

interested in Georgie

Bull's torch and peered

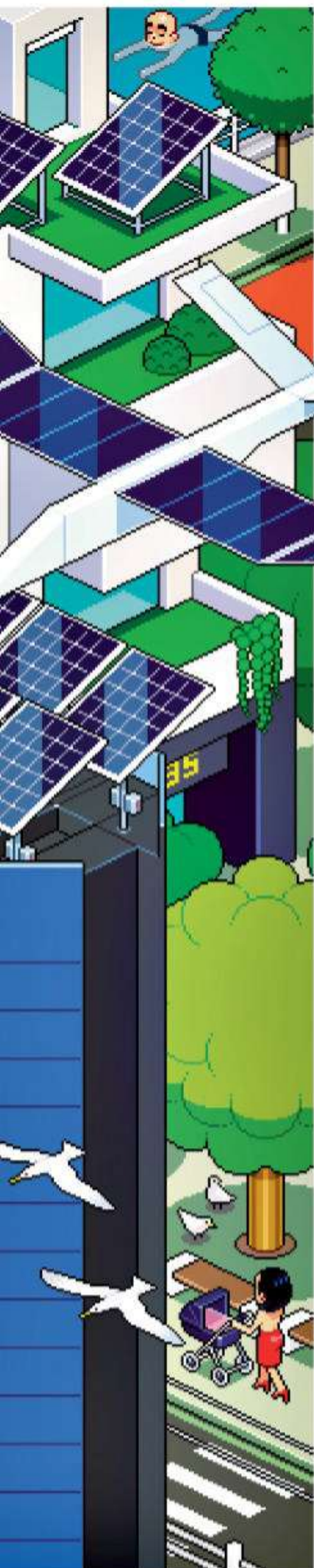
over a small pebble to

see what was going on.





SUPER TOTTO



WHAT DOES A WORLD LOOK LIKE
WHERE WE'VE TAKEN THE STEPS NEEDED
TO LIMIT GLOBAL WARMING?
ADAM VAUGHAN FAST-FORWARDS TO 2050

FEW of us have fully digested the transformation of economies and our own behaviour that is implied by the existential fight against climate change – even as last month's report from the Intergovernmental Panel on Climate Change (IPCC) laid bare how little time we have left to accelerate the transition to a cleaner world.

It isn't that the world is lacking in commitments. If you live in the UK, EU, US or scores of other places, the declared aim is that you should be living somewhere with net-zero greenhouse gas emissions within three decades. Eleven nations – Canada, Denmark, France, Germany, Hungary, Japan, Luxembourg, New Zealand, Spain, Sweden and the UK – have already written this goal into law, and dozens more have signalled their intent to do so.

But most of us are lacking a visualisation of what daily life will be like at net zero, from our homes and food to travel and the landscapes around us. "I think we probably don't do that enough. It's a really helpful thing to do, to take away the fear and get people excited," says Mike Thompson at the Climate Change Committee (CCC), a statutory adviser to the UK government.

What follows is an attempt to fill in that gap and show you a day in the life of Isla, a child today, in 2050. By its nature, it is speculative – but it is informed by research, expert opinion and trials happening right now.

TODAY IN 2050

When the alarm goes off, the torrential rain outside is almost enough to send Isla back under her duvet. That's unusual for a late summer day. Drier and much hotter summers have been the norm for years here in the south of the UK. Mind you, unpredictable weather has become a feature of life in recent years.

Fortunately, Isla's home is the same steady 20°C all day long, comfortable and draught-free. The idea of a home where the temperature fluctuates constantly, like her parents used to have, is alien to her. She doesn't even know what the temperature is. An algorithm learned the warmth she prefers. Walking downstairs, Isla glimpses the unit in her garden that extracts heat from the air. Apart from some relatives in Yorkshire who still have hydrogen boilers from a big trial back in the 2020s, everyone she knows has a heat pump like this.

Making a cup of tea, Isla's kettle looks the same as the ones her mother used three decades ago. But 95 per cent of the electricity it uses comes from wind and solar farms, a far cry from 40 per cent in 2020. The milk in her tea came from a cow. She knows that is old-fashioned, but still seeks it out in the boutique section of her online supermarket, despite the ubiquity of plant-based milk.

Today is a rare in-person day at the office. Unusually, Isla owns rather than shares an electric car – it is one of the reasons she never bothered getting a separate home battery. Charging it overnight when there is a glut of ➤

wind power sees prices flip, so firms pay to use it. Her battery stopped charging a few minutes ago, so it is warm and at its most efficient.

Driving out of town, she passes rows and rows of houses and offices with green roofs. They soon give way to a former industrial estate, now rows of boxes that look a little like jet engines, fans whirring away. They are machines to capture carbon dioxide directly from the air, fitted a few years ago by a big CO₂ removal firm, Shell.

A brief journey up the motorway sees her whizzing past the lorry lane with its tram-style power cables that run above the trucks. There are more power pylons running alongside the road than when she was a child.

Back-to-back meetings at the office are followed by lunch out. Walking to a restaurant, she passes through the greenery of the Old Car Park, the wooded enclave that the local council deliberately allows to flood in winter. Isla and her dining companion both choose a burger. Not from an animal, obviously. Beef is on the menu as a high-end rarity with lots of words expended to explain its husbandry and genetic editing to curb methane emissions. It is too expensive for this casual lunch. A plant-based burger is cheaper, and does just fine.

Sleepy afterwards, Isla takes a half-day and heads home for a walk to wake herself up. The first growth phase of the Great Southern Forest seems to go on forever these days, and it is a welcome refuge from the mid-afternoon heat fast evaporating the morning's rain. Emerging from the wood, she walks uphill through the looming elephant grass that will soon be harvested to make fuel for planes flying overhead. From the highest point, she can see a handful of cattle and sheep. She finds it hard to imagine that these rolling hills were once covered with them.

Later on, her home is still cool. Like most of her neighbours, she has no air conditioning, instead having automatic shutters for her windows, a big awning for shade and a natural ventilation system. That evening, she calls her friends. One sits chatting with the sea behind her, the 236-metre-tall blades of the Hornsea Three wind farm just about visible. Another friend in London bemoans the second

days above 38°C they have had this year.

Winding down later, Isla plans a holiday. She skims past the long-haul flights, which some of her friends still take despite the rising cost of mandatory CO₂ removal and the moral opprobrium that flying attracts. Happily, as she scrolls on her phone before bed, she finds the perfect option to dream about: a luxury train tour of Norwegian vineyards.

BACK TO THE PRESENT...

Where do the changes to Isla's life in 2050 come from, and how likely are they to come to pass? Read on for the background in six crucial areas of our everyday lives – based on the situation in the UK, but with lessons for elsewhere in the world too (see “The global net-zero view”, right).



HOMES

Homes in 2050 will look similar to today's, but will feel and run differently behind the scenes. Energy efficiency and insulation will be much improved, even for older homes. Everything that can be electrified will be. Offshore wind farms including Hornsea Three, approved in December 2020 and capable of powering 2 million homes, will be the backbone of a 95 per cent low-carbon grid.

In the UK, more than four-fifths of homes are heated with gas boilers today. By 2050, they will probably be kept warm with a heat pump, effectively a reverse refrigerator that extracts heat from the air or ground to warm a fluid that is compressed to raise the temperature even higher. “It's the most common scenario in our research,” says Thompson.

About 30,000 are being installed a year today – versus more than a million gas boilers annually – but the UK government is planning a “heat and buildings strategy”, due out this month, to meet a target of 600,000 a year by 2028. Falling costs as more installers enter the market should help. New homes and homes off the gas grid will spearhead the take-up. Meanwhile, a trial of a hydrogen-powered village is planned to take place by 2025, with a town possibly following by 2030.

Gas hobs for cooking will have made way for electric induction hobs. Combustion may not be entirely a thing of the past – the odd home may still burn wood if it hasn't been banned because of growing concerns about particulate pollution.

Opinions differ on how engaged or not we will be with our energy use. “I think we will be more conscious energy consumers. Isla might well be thinking more about the energy she uses that day,” says Alice Bell at the non-profit organisation Possible. “They might check the weather so that if it's sunny they know they have a cheaper energy tariff and set the washing machine and other devices.” By contrast, Thompson suspects energy won't be something that Isla worries about, with smart systems and algorithms governing much of our home energy use, such as software being used in the Living Lab, a smart home testing environment developed by the UK Energy Systems Catapult.

One possible change is more homes needing air conditioning, says Bob Ward at the London School of Economics. Thompson hopes that doesn't happen, less because of the extra energy – demand is low in summer and solar power output is high – but because of the heat that air-con units generate. He thinks natural shading measures and ventilation will be enough for most homes.



FOOD AND WASTE

What we eat will have changed, with a big shift towards plant-based diets, but probably not to the level of the all-vegan, meat-mocking world depicted in *Carnage*, a satirical film by comedian Simon Amstell. “I don’t think we will be a nation of vegans,” says Rebecca Willis at Lancaster University. The CCC’s central scenario envisages a world in which all meat and dairy consumption is down by 35 per cent. It sees that as an acceleration of current trends: meat consumption per person fell by 6 per cent between 2000 and 2018 in the UK. A more extreme scenario sees a 50 per cent fall as possible.

“There will be a big shift towards plant-based diets, but it won’t be a vegan world”

Mark Maslin at University College London thinks dietary shifts will be driven more by health than climate concerns. In a chapter on a 2050 “Ecotopia” in his book *How to Save Our Planet*, he writes: “Pandemics of the early 21st century helped shift global diets to be much more vegetable-based, helping to improve everyone’s health.”

Ward agrees, and says obesity emerging as a risk factor for covid-19 will be another push towards more fruit and vegetables in our diets. Most “meat” will probably be fake, of the plant-based kind popularised by Impossible Food and Beyond Meat, says Bell. Real meat and lab-grown meat will be more premium and niche options, she thinks. That could be driven by carbon taxes, something the UK government is reportedly considering.

The amount of waste that Isla produces at home in 2050 should be down by nearly half from today, according to the CCC. How that happens remains to be seen. It might mean better packaging in the first place, more reusable packaging such as that offered now by US company Loop in a handful of countries, or more boxes to sort recycling into. “We will need better systems for separation and collection,” says Thompson.

THE GLOBAL NET-ZERO VIEW

Some of the things in Isla’s life in the UK will be replicated in other nations, regardless of their income levels. The decarbonisation of electricity grids through wind and solar power and the electrification of vehicles are both seen as vital for many countries, including China. The US is among other nations looking to heat pumps.

In regions close to the equator, there will be a greater focus on innovations in cooling. That is why a test lab to create the homes of the future, Energy House 2.0 in Salford, UK, will be able to simulate different global climates.

Dietary changes will play out differently around the world. In places such as China, meat consumption is still rising. In his recent book *How to Avoid a Climate Disaster*, Bill Gates writes that cultural reasons mean stark diet shifts in some countries may be unrealistic.

One simple difference will be when the Islas of other nations might experience this life: China’s target, for example, is carbon neutrality by 2060, not 2050. India hasn’t set a long-term date for net zero yet, with Prime Minister Narendra Modi noting on 22 April that the average person in India has a 60 per cent smaller carbon footprint than the global mean.

A warmer world with more extreme weather could put more stress on some governments. “A climate strategy requires a very active role by government. I would worry in some countries, you will see political breakdown as a result. It could also result in democratic renewal in other countries,” says Rebecca Willis at Lancaster University.



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TRANSPORT

Greater adoption of hybrid or remote working will probably have curtailed some commuting in many parts of the world, with the current pandemic just one driving factor. But travelling is likely to look familiar, just with most cars and vans running on electricity or another “energy carrier” such as hydrogen, rather than oil.

The need to give more space over to cycle lanes and green spaces for carbon capture and biodiversity means there should be fewer cars, says Bell. More of those will be shared, via some evolution of today’s car clubs and ride-hailing services such as Uber. The bus taking Isla’s children to school will probably be battery-electric too, says Thompson. Heavy-duty trucks could use tram-style overhead lines to recharge; small pilot schemes are already in place in Sweden and Germany. Altogether, writes Maslin in his book, this means that in 2050 “the air is cleaner than it’s been since before the Industrial Revolution”.

Cars will be charged when there is the least pressure on electricity grids, such as overnight. They will feed back to the grid too, acting as an aggregated mega-battery that can supply the grid as needed to smooth out the variable nature of wind and solar power. Hayden Wood at UK green energy firm Bulb says he is “absolutely convinced”

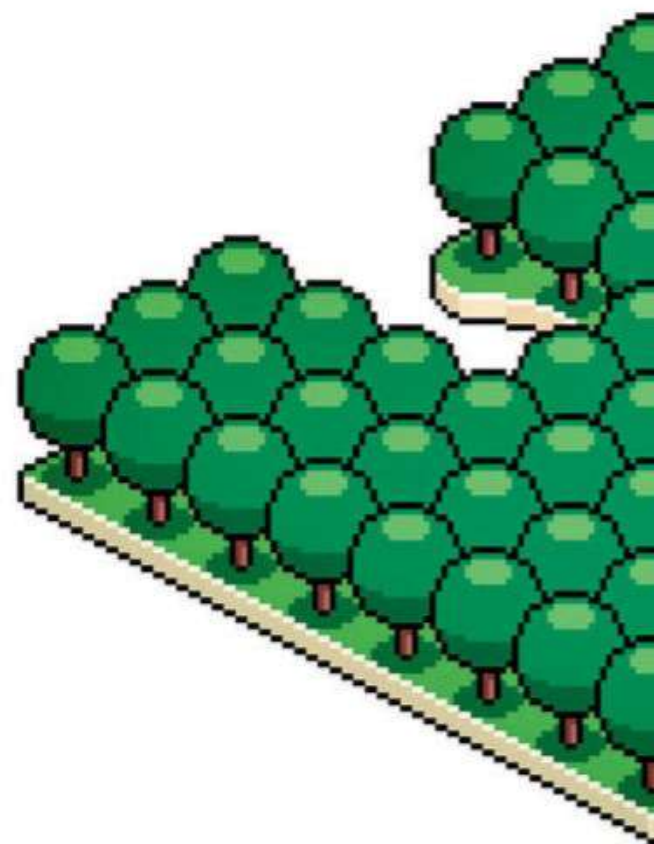
such vehicle-to-grid technology, which currently exists only in pilot form, will scale up. “It makes no sense to have gigawatts of battery capacity in people’s cars [that is] not being used to help balance the grid,” he says.

Electrification won’t be confined to cars. Trains are more likely to be electric, replacing the last diesel ones today, with low-use lines perhaps using hydrogen, says Thompson. Bell even envisages solar panels lining tracks and running green electricity direct to the rails, owned by the commuters on those trains, similar to today’s “Riding Sunbeams” trial in the south of England.

Trains will have to replace many shorter plane journeys, but flying isn’t going away: the CCC expects flights to increase by mid-century after a brief downward blip through and after the covid-19 pandemic. Aviation and farming will probably be the UK’s two biggest sectors still releasing greenhouse gases by 2050.

The CCC’s best estimate is that 17 per cent of planes would run on biofuels and 8 per cent on synthetic jet fuel, with the rest coming from oil. If Isla books a flight, there won’t be a box to tick for carbon offsets because all flights will be offset through some form of carbon removal, such as the direct CO₂ air capture units on the outskirts of Isla’s town. The CO₂ removal and alternative fuel could add around £14 to the cost of a 2050 London to New York flight, after factoring in fuel savings from more efficient planes, the CCC estimates.

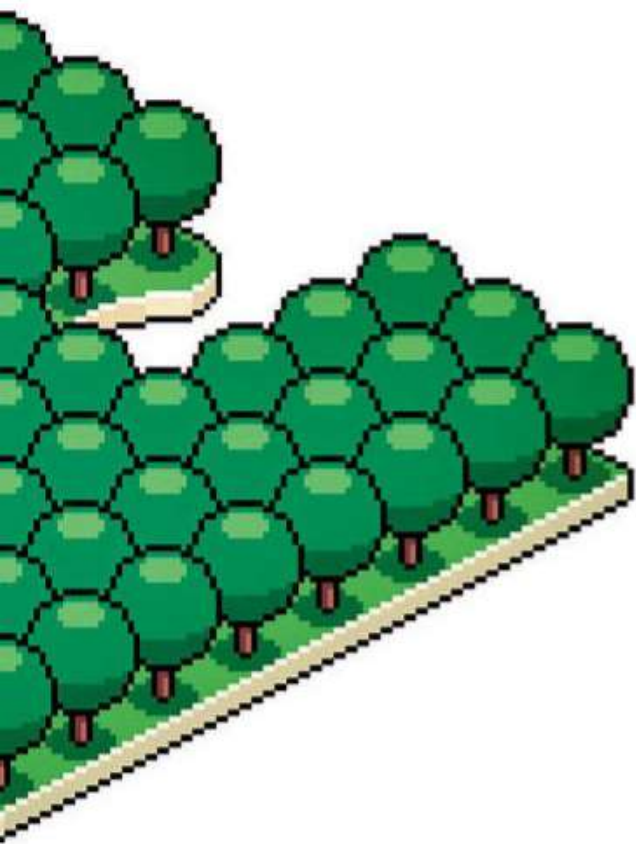
“Trains will have replaced many shorter journeys, but flying isn’t going away”



LAND USE

Gazing down from those planes, the landscape should appear drastically different. “I can’t imagine the countryside will look as it does now,” says Willis. “There will be a lot more tree cover, all over the country. And a lot of mixed agriculture, not the big, flat, green fields we see at the moment.” To remove and store CO₂, peatland and forests need to be restored. The CCC envisages shifts towards plant-based diets freeing up around a fifth of farmland for other uses, such as tree-planting. Energy and food production will coexist on some land; Willis’s colleagues at Lancaster University predict more solar panels in fields for the few sheep left grazing.

When it comes to ways of removing CO₂, says Thompson, “we think the tree is the cheapest and most efficient way of doing this”. The CCC expects forest cover to increase from 13 per cent of UK land now to around 18 per cent by 2050, with a mix of conifers and deciduous species. “The great forests of the past will be returned gradually across the country,” says Ward. There will be more energy crops too, such as *Miscanthus* grasses. More land could be freed up for rewilding and reintroducing species such as beavers, thinks Maslin. The landscape is unlikely to be carpeted in fans extracting CO₂ from the air. The higher costs mean such machines will only cover about 10 square kilometres



compared with 10,000 square kilometres of extra forest, says Thompson.

Not all the changes to the landscape will be considered positive. There is a consensus among the CCC and other bodies including the UK National Grid that there will be a big increase in electricity generation, so as to cope with everything from heat to transport being electrified. Unless energy production becomes incredibly decentralised, with far more buildings having solar power, Willis says there will be more transmission infrastructure, such as pylons and substations, to take supplies from North Sea wind farms to homes and factories.

"The great forests of the past will return gradually across the UK"

WEATHER

While there are many things we can't say for certain about life in 2050, some things about the lives of Isla and her peers are clear. Most obviously, they will live in a warmer world, even if society does succeed in making the shift to a net-zero economy.

Today's 1.1°C of global warming above pre-industrial levels will probably already be around 1.5°C by mid-century, a global average that will mask bigger jumps in places such as the Arctic. In the UK, flooding from torrential rainfall is expected to be the biggest climate impact. Extreme temperatures could be a hazard too: the UK Met Office says the possibility of 40°C days will be 10 times more likely later this century than it would be without anthropogenic climate change. "There will be more extreme weather in this country and elsewhere. Isla will be much more used to a conversation about climate impacts," says Willis.

The hope is that society will have adapted to more volatile weather. In cities, green roofs and more green spaces will both be far more common, partly to lock up CO₂ but critically to offset the urban heat island effect that makes cities hotter than the surrounding area, says Maslin. In recent years, the UK government has also allocated more funding for natural solutions to flooding, such as deliberately allowing green spaces like Isla's park to flood.



SOCIETY

Many changes we will see between now and 2050 won't be connected with climate change – think of the jump from a pre-internet life 30 years ago to today's hyperconnected society. Even the shifts to hit net zero are unlikely to change some fundamentals. "We're not suddenly going back to the Stone Age", says Maslin. "Saving the planet just makes everybody's lives better, but we're not going to radically change that we get born, get looked after by modern medicine, we go to school, we go to work and then we try to live as long as possible."

One possibility is that the engagement with the public required to introduce technology and behaviour changes for net zero – akin to the 2020 citizens' Climate Assembly UK – could invigorate democracy at a local level. "It would be lovely to think of a utopia where greening and saving the planet makes people more engaged with local politics," says Maslin. Maybe that will happen, he says, but "I'm a bit more cynical".

One thing is clear: with the world warming rapidly, sticking with the status quo isn't an option. As Bell says: "Change is coming. It's either coming from changes we make as society or it's going to come from the skies or the soil." ■



Adam Vaughan is chief reporter for *New Scientist* and writer of *Fix the Planet*, our weekly climate change newsletter

Out of spite

The dark side of human nature has some unexpected upsides, says **Simon McCarthy-Jones**

A MAN buys a house next door to his ex-wife and installs a 4-metre bronze statue of a hand, middle finger raised, facing her window. A prominent investor buys a company so he can fire the management he dislikes, even though he stands to lose money. People take their time at the checkout to annoy the next customer, buy gnomes for their garden to antagonise a neighbour and slow down to annoy tailgaters, even though it puts everyone in danger.

Examples of spiteful behaviour, harming another at some cost to yourself, aren't hard to find. As a psychological game where no one wins, spite is puzzling: we may wonder why it wasn't weeded out by evolution long ago. Instead, in a competitive era of identity politics, all too often played out on social media, it seems more prevalent than ever.

Yet, compared with other social behaviours like selfishness, cooperation and altruism, there has been relatively little psychological research into why we do it. With potentially far-reaching consequences for both political stability and individual mental health, it has never been more important to understand this dark side of human behaviour.

For many years, most of the research into spite came from the field of behavioural economics: the study of how human decision-making differs from what you would expect from a purely rational point

of view. Classical economists dreamed up the concept of *Homo economicus*, a person who only ever acts to maximise their own rewards. If offered a choice between something and nothing, *Homo economicus* would always take what is on offer.

In experiments, however, this isn't how everyone behaves. In the Ultimatum Game, created by economist Werner Güth at the University of Cologne in Germany in 1977, one volunteer is given a pot of money and asked to decide how much of it to share with another player. If the other player accepts the offer, both will keep their share of the cash. But if the other player refuses the offer, both leave empty-handed. They only play the game once.

In Güth's experiments, approximately half of the volunteers rejected offers of 20 per cent or less of the pot, leaving both players with nothing. At the time, these spiteful rejections were explained as being due to people's anger at being treated unfairly, motivating them to pay a price to punish the other. Indeed, analysis of facial muscles during the Ultimatum Game suggested that unfair offers led to anger and disgust, which motivated players to punish the non-sharer. Brain-imaging studies suggest that the brain also processes people's faces differently when they have violated norms of behaviour, treating them as less face-like. This suggests that, in our anger, we dehumanise norm-violators, which makes it easier to set



RUBY FRESSON



**“Social media
cancelling allows
us to climb the
social ladder with
a public display of
‘selfless’ virtue”**

aside our empathic nature and punish them. The Ultimatum Game is a one-shot situation, but real life is not: spite evolved to persuade people to treat us better next time.

But in the past decade or so, cracks have appeared in the idea that spite evolved to make unfair people behave better. Further experimental games found that people didn't only spite others who acted unfairly. They would also spite those who acted fairly, particularly when they could hide behind anonymity. Other studies found that spitefully punishing someone didn't seem to work as a way of persuading them to treat you better in future. If spite evolved for a reason, increasing cooperation didn't seem to be it.

So, if boosting cooperation doesn't explain spite, what does? One clue comes from the fact that, as a social species, our position in the pecking order matters to our survival. Spite may have its roots in the desire to get ahead of others (dominance) and to stop others getting ahead of you (counter-dominance).

It is clear that the human desire for dominance has deep evolutionary roots, but so, it appears, does our counter-dominant drive. Anthropologists argue that our hunter-gatherer ancestors evolved an egalitarian instinct to pull others down when they threatened to pull ahead. When Christopher Boehm, an anthropologist at the University of Southern California, examined the social structures of contemporary hunter-gatherer societies, he found they were strongly egalitarian, at least in male-male relations. If a male hunter-gatherer got above himself and tried to take more than his share, or even if he had brought home a particularly impressive kill that would benefit everyone, but also inflate his status, he could be punished.

This may explain a seemingly confusing aspect of spite: that we are capable of spiting those whose actions have materially helped us. When someone helps us, but in a way that boosts their own social status, our spiteful side kicks in to cut them down to size.

This phenomenon is called do-gooder derogation and it has been seen both in lab based economic games and in real life. In one such game, all players earn money if they pay into a group investment fund. Even though everyone benefits from the actions of generous investors, some players were happy to give up some of their earnings to see those of the more generous investors destroyed. In real life, this phenomenon may also explain why vegans attract so much ire, particularly on social media – they are ➤

A mean streak?

Spiteful behaviour has long been observed in lab experiments, but there has been surprisingly little psychological research into what it actually is and how it varies from person to person.

The first questionnaire specifically designed to answer these points was only published in 2014. Perhaps unsurprisingly, the questionnaire found people scoring higher on spitefulness also tended to score higher on measures of aggression, psychopathic personality traits and impulsivity. But problematic personality traits weren't the only issue. Spiteful people were also more likely to report symptoms of psychological distress in their everyday lives, suggesting that perhaps poor mental health and social inequality are important factors.

Another individual difference relates to a person's "social value orientation", which is how they like events to play out in relation to themselves and others. The psychologist Paul van Lange at VU University Amsterdam in the Netherlands found that people usually have one of three social

value orientations: prosocial, individualistic or competitive.

To find out which you are, imagine you and another player are to be awarded points. The more you get, the better. You have three options:

- A: 480 points for you, 480 points for the other person.
- B: 540 points for you, 280 points for the other person.
- C: 480 points for you, 80 points for the other person.

Van Lange's research found that around 70 per cent of people chose option A (prosocial). About 20 per cent chose B, using rational thinking to maximise their pay-off (individualistic). But around 10 per cent of people chose C (competitive). Such people act spitefully by taking less than the maximum points available while minimising the amount the other gets. Yet in the process, they maximise their advantage over the other player and boost their dominance.

In real life, it may be an idea to keep the prosocial close, but the competitive even closer.

perhaps being punished for living out a lifestyle that is seen to be morally purer than most. Hillary Clinton's campaign in the 2016 US presidential election, which focused on the rights of women and minority groups, may also have triggered do-gooder derogation and contributed to her defeat.

To make things more complicated, both the presence and absence of an audience can encourage spiteful acts. In a study using another economic game, called the Joy of Destruction, volunteers worked to assess the quality of magazine adverts. Everyone was paid fairly, according to how much work they had done. Participants were then given the option to destroy some of the other players' earnings. If they had to do this publicly, hardly anyone chose destruction. Yet, when given a blanket of anonymity, around 40 per cent opted to destroy some of the other players' fairly earned money. This can be seen on social media, too. Anonymity helps to release our spiteful side.

Spite for likes

On the other hand, some studies show that an audience is often required to unleash our social conscience. If we see someone hurt a third party, we are more likely to take a hit to punish that person if others are watching. If there is no audience, and hence no social brownie points available, hardly anyone does this. Social media "cancelling", where a public figure loses popular support after a perceived transgression, draws on this. A watching audience, ready to pile on with rewarding likes, encourages people to punish those who are seen to transgress against others, allowing the punisher to climb the social ladder by their public display of "selfless" virtue.

In 2019, Nichola Raihani, a psychologist now at University College London, and Redouan Bshary, a behavioural ecologist now at the University of Neuchâtel in Switzerland, added a darker twist to the story. They argued that we have overestimated how much spiteful punishment is about increasing cooperation. Instead, it seems to be more about retaliation, often driven by envy, so it is more a method of coercing individuals into submission and establishing dominance hierarchies than upholding what we think is right. We may delude ourselves into thinking we are punishing for noble purposes, when in reality we are concerned with inflicting harm and gaining status.

There is also the uncomfortable finding that acting on our spiteful impulses can be pleasurable, particularly when we find



THOMAS TRUTSCHEL/PHOTOTHEK VIA GETTY IMAGES

A tailgating driver can unleash a spiteful urge to slam on the brakes



ourselves in a highly competitive environment. Both laboratory and real-life studies show that a more competitive world tends to increase spite. For example, the Nama people of southern Namibia live off their livestock, which grazes on commonly managed land. Research has found, using a variant of the Joy of Destruction game, that for every Nama living on the high-quality land willing to act spitefully, two on the low-quality land, where competition for resources is higher, are willing to act spitefully.

Intriguing research from Molly Crockett, a neuroscientist at Yale University, and her team suggests a biological mechanism for how competition and scarcity may encourage spite. One of the building blocks of serotonin, a neurotransmitter linked to feelings of well-being, is tryptophan, an essential amino acid that we can only get from our diet. If food becomes scarce, then we are likely to ingest less tryptophan and have reduced serotonin levels. This may encourage spitefulness as a means to grab limited resources.

To test this, Crockett's team asked people to play the Ultimatum Game. But before playing,

participants either drank a normal beverage or one containing a tryptophan-depleting chemical. Those who had the tryptophan-depleting drink acted more spitefully when they played the game. In another study, the researchers found, conversely, that enhancing serotonin function made people less likely to harm others. Brain-imaging research by Crockett's team suggested that reducing serotonin increased spitefulness because it made harming others more pleasurable. Reducing serotonin levels led to increased activity in the dorsal striatum, a brain region involved in anticipating rewards, when people were punishing others.

If spite really is as nasty as it seems, perhaps we should take steps to keep it to a minimum. At an individual level, one option is to remove anger from the equation. Studies in which activity in the brain's emotional circuitry was temporarily reduced with drugs, such as benzodiazepines, or via neurostimulation – a small electrical current applied to the scalp – showed that people acted less spitefully in the Ultimatum Game afterwards. More practically, simply delaying

a decision on how to react to an offer in the Ultimatum Game lets anger decay and spiteful acts lessen.

Another way to reduce our spiteful tendencies is to develop our capacity for cognitive reflection, a measure of the ability to override gut responses in favour of rational thought. Meditation training has also been shown to reduce spiteful rejections in the Ultimatum Game, in part by allowing people to uncouple their emotional responses from their behaviour. When experienced Buddhist meditators received offers of \$1 from a \$20 pot in the Ultimatum Game, they were half as likely to reject it as non-meditators.

A force for good

This raises an important question: should we always try to reduce spite? Not acting spitefully, and accepting unfairness, could leave us vulnerable to continued exploitation. When standing up to injustice is required, but will inevitably come at a personal cost, spiteful behaviour may be just what is needed. A willingness to spite, to press our personal nuclear button, may be the final weapon we have in this situation.

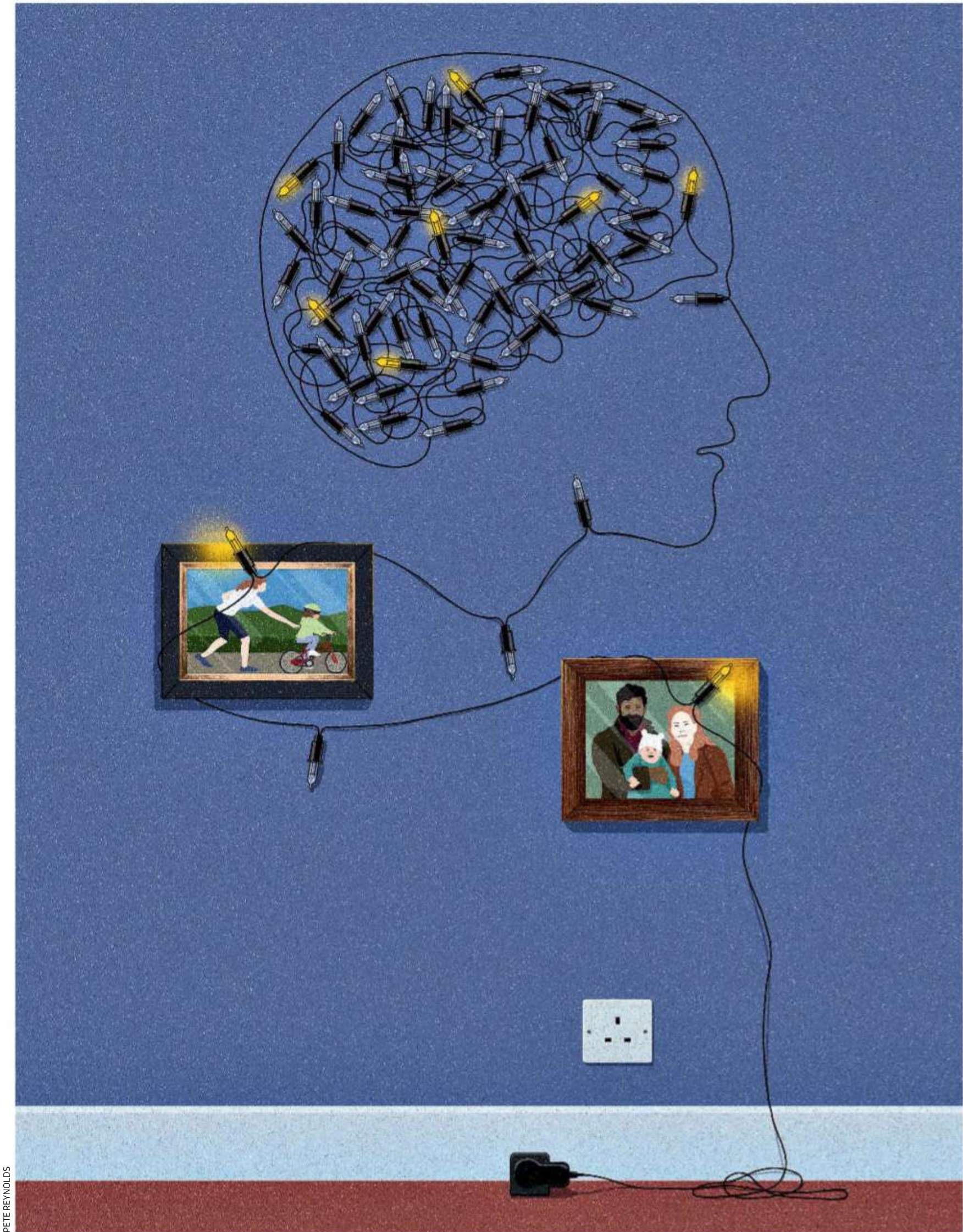
Having a spiteful side also seems to boost performance in competitive situations. In experiments, spiteful and non-spiteful people, as assessed by a form of sharing task, were found to perform equally well on a simple maths-based activity. But when a prize was offered for better performance, the more spiteful surged in front, suggesting that their greater willingness to get ahead of others could pay dividends.

So, rather than trying to avoid spite, we should perhaps aim to be more selective about how we use it – aiming it at injustice rather than simply against those with more social or material clout. Using our spite at the right target, in the right way, at the right time could be a powerful tool to improve society.

Buddhism has the concept of wrathful compassion, which involves acting with love and courage to confront another for their own sake. Spite, done with the aim of wrathful compassion, could prove to be a force for good. Whether that reveals spite to be an upside of human nature will ultimately depend on which end of it you wind up on. ■



Simon McCarthy-Jones is a psychologist at Trinity College, Dublin. His book *Spite... and the upside of your dark side* is out now



PETE REYNOLDS

Illuminating consciousness

A fulfilling explanation for how physical matter gives rise to conscious experience is beginning to come to light, says neuroscientist **Anil Seth**

THE nature of consciousness is truly one of the great mysteries of the universe because, for each of us, consciousness is all there is. Without it, there is no world, no self, no interior and no exterior. There is nothing at all.

The subjective nature of consciousness makes it difficult even to define. The closest we have to a consensus is that there is “something it is like to be conscious”. There is something it is like to be me or you, and probably something it is like to be a dolphin or a mouse. But there is – presumably – nothing it is like to be a bacterium or a toy robot. The challenge is to understand how and why this can be true. How do conscious experiences relate to the cells and molecules and atoms inside brains and bodies? Why should physical matter give rise to an inner life at all?

Some people fear science may not be up to the task. They point out that you can’t precisely control or observe felt experiences. Some even question the idea that physical mechanisms can ever explain consciousness.

I disagree. I believe that science is capable of explaining consciousness, but only if we stop treating it as a single big mystery requiring a humdinger solution. Instead, we must break it down into its various related properties and address each in turn. As we progressively explain why particular patterns of brain

activity map to particular kinds of conscious experience, we will find that the deeper mystery of consciousness itself begins to fade away.

Humans have pondered the relationship between physical matter and conscious experience for a long time. In the 1600s, René Descartes divided the universe into “mind stuff” (*res cogitans*) and “matter stuff” (*res extensa*), raising the conundrum of how the two might ever interact. His dualist perspective is now accompanied by a bewildering array of alternatives, ranging from illusionism – the proposal that consciousness doesn’t exist, at least not in the sense that we normally think of consciousness – to panpsychism, which posits that consciousness is fundamental and ubiquitous. The relatively orthodox scientific view of physicalism – the view that I find most appealing – is that consciousness is related to or emerges from physical matter. The question is how.

In the 1990s, the philosopher David Chalmers made an influential distinction between the “easy” and “hard” problems of consciousness. The easy problem is really a series of problems. These involve understanding how the brain, in concert with the rest of the body, gives rise to functions like perception, cognition, learning and behaviour. These problems aren’t actually easy at all; the point is that there is no conceptual mystery, that these problems can be solved in terms of physical mechanisms, however complex and hard to discern these mechanisms may be. Chalmers’s hard problem, on the other hand, is the enigma of why and how any of this should be accompanied by conscious experience at all: why aren’t we just meaty robots, without an inner universe? The temptation is to think that solving the easy problems would get us nowhere at all in solving the hard problem, leaving the brain basis of consciousness a total mystery.

Fortunately, there is an alternative, which I’ve come to call the “real problem” of consciousness: how to explain, predict and control the various properties of consciousness in terms of physical processes in the brain and body. The real problem is distinct from the hard problem, because it isn’t – at least not in the first instance – about explaining why and how consciousness is ➤

part of our universe. It is also distinct from the easy problems, because it doesn't sweep the subjective, experiential properties under the carpet. The real problem isn't a completely new way of thinking but, for me, putting things in terms of explanation, prediction and control has helped to crystallise what a successful science of consciousness should look like, since these are the criteria that are applied in most other fields of science.

Take, for example, the visual experience of redness. The hard problem asks why there is such an experience at all, while the easy problems encompass all the processes and outcomes associated with light of a particular wavelength entering the eye. From the perspective of the real problem, we want to know what it is about specific patterns of activity in the brain that explains (and predicts and controls) why the experience of redness is the way it is. Why isn't it like blueness, or toothache, or jealousy?

This approach has something of a pedigree. Not so long ago, biologists and chemists doubted that the property of "being alive" could ever be explained mechanistically.

Nowadays, although there are still many things about life that remain unknown, the idea that being alive requires some special sauce has long been retired. The hard problem of life wasn't so much solved as dissolved.

Now, it is true that life isn't the same thing as consciousness. Most conspicuously, the properties of life are objectively describable, whereas the properties of consciousness exist only in the first person. But this isn't an insurmountable barrier; it mostly means the relevant information, because it is subjective, is harder to collect.

Part of the strategy in dissolving the hard problem of life was to stop treating it as one big scary mystery in need of a eureka solution, and instead as a collection of related properties, each addressable somewhat separately. For consciousness, there are many ways to cut the cake. In my book *Being You: A new science of consciousness*, I distinguish between conscious level (how conscious you are, as in the difference between general anaesthesia and normal wakeful awareness), conscious content (what you are conscious of) and conscious self (the experience of "being



CHRISTOPHER ANDERSON/MAGNUM PHOTOS

Theories of consciousness

In the early days of modern consciousness science, back in the 1990s, researchers focused on identifying empirical correlations between aspects of conscious experience and properties of brain activity. This search for the "neural correlates of consciousness" was motivated in part as a response to concerns, pervasive through much of the 20th century, that consciousness lay beyond the remit of science altogether. But despite its many successes, this approach is limited because correlations aren't explanations, no matter how many you identify.

In recent years, however, there has been a blossoming of neurobiological theories of consciousness. This is a sign of the field's growing maturity, because it is only when couched

in terms of a theory that experimental findings can deliver a satisfactory understanding of consciousness.

There are currently four main theoretical approaches in consciousness science. According to higher-order theories, a mental state is conscious when another mental state – higher up in a hierarchy – says that it is. For these theories, the devil is in the detail about what kinds of "higher-order" representations count for consciousness. Global workspace theories propose that mental states are conscious when they are broadcast widely throughout the brain, so that they can be used to flexibly guide behaviour. A good way to think about global workspace theory

is that consciousness depends on "fame in the brain" – conscious mental states have access to a wide range of cognitive processes in ways that unconscious mental states don't. These two theories focus on functional aspects of consciousness and emphasise frontal (at the front) and parietal (towards the back and off to the sides) brain regions.

By contrast, integrated information theory focuses on phenomenological aspects of consciousness – what it is like, experientially – and proposes that consciousness is associated with a posterior cortical "hot zone", located towards the back of the brain and including parts of the parietal, temporal and occipital lobes. According to this theory, consciousness

depends on the ability of a system to generate integrated information.

The fourth approach, known as predictive processing, is more indirect, being used primarily to build explanatory bridges between aspects of consciousness and their underlying neural mechanisms. There are several examples of this approach, ranging from those which associate consciousness with top-down signalling in the brain to my own "beast machine" theory (see main story). For these theories, the idea is that by progressively accounting for diverse aspects of consciousness, they can ultimately shift from being theories for consciousness science towards being theories of consciousness itself.



Big Thinkers series: A New Science of Consciousness

Join Anil Seth at our online event on Thursday 9 September

at 6pm BST, or catch up on demand [newscientist.com/events](https://www.newscientist.com/events)



The aim is to explain why redness isn't like blueness or pain

you" – or "being me"). By developing accounts that explain, predict and control these different aspects of consciousness, my belief is that a fulfilling picture of all conscious experience will come to light.

Let's focus on content and self. My strategy for explaining these properties of consciousness is based on an increasingly popular theory in cognitive neuroscience called predictive processing.

The bedrock idea is simple. Imagine that you are your brain, locked inside the bony vault of the skull, trying to figure out what's out there in the world – a world that, from the perspective of the brain, also includes the body. All you have to go on are noisy and ambiguous sensory signals, which are only indirectly related to what's out there, and which certainly don't come with labels attached ("I'm from a cup of coffee! I'm from a tree!"). Perception, in this view, has to be a process of inference – of neurally implemented probabilistic guesswork. When I see a red coffee cup on the table in front of me, this is because "red coffee cup" is the brain's best guess of the hidden,

and ultimately unknowable, causes of the corresponding sensory signals. When I experience the glow of a sunset, or the sharp taste of an adventurous cheese, that too is a perceptual best guess.

How are these perceptual best guesses arrived at? According to predictive processing, the brain is constantly calibrating its perceptual predictions using data from the senses. The predictive processing theory has it that perception involves two counterflowing streams of signals. There is an "inside-out" stream, cascading downwards through the brain's perceptual hierarchies, that conveys predictions about the causes of sensory inputs. Then there are "outside-in" prediction errors – the sensory signals – which report the differences between what the brain expects and what it gets. By continually updating its predictions to minimise sensory prediction errors, the brain will settle and resettle on an evolving best guess of its sensory causes, and this is what we consciously perceive.

Perception, in this view, isn't a passive registration of an external reality. It is an active construction, a kind of "controlled hallucination", in which the brain's best guesses are tied to the world – and the body – through a continuous process of prediction error minimisation.

Predictive processing isn't a theory of consciousness, in the sense that solving Chalmers's hard problem would require (see "Theories of consciousness", left). Instead, at least at first, it is best thought of as a theory for consciousness science, in the real problem sense. It provides a method for building explanatory bridges between neural mechanisms and aspects of what conscious experiences are like, from the perspective of the person experiencing them.

This is what my colleagues and I have been

doing in my laboratory at the University of Sussex, UK. Some of our experiments are very simple – for example, finding that people consciously perceive expected images more quickly, and more accurately, than unexpected images. But the really exciting work is taking us deeper into the phenomenology – the "what-it-is-like"-ness – of conscious experiences. In one example, we are investigating the phenomenology of different varieties of visual hallucination in terms of their dependence on different kinds of perceptual prediction.

Perceptual architecture

Some hallucinations, such as those due to psychosis or neurodegenerative disease, can be complex, featuring rich perceptual scenes experienced as being real. Others, such as those arising from progressive visual loss, can be relatively simple and aren't experienced as being continuous with the real world. These differences can be simulated by novel neural network architectures that deploy perceptual predictions in different ways. These neural networks serve as computational models of the brain basis of visual experiences, and we can check their output by asking people who experience hallucinations to rate what they come up with. We are now extending this approach – which we call "computational phenomenology" – to other, more fundamental aspects of perceptual experience, like the sensation of time passing and the three-dimensional structure of visual space.

By progressively accounting for the deep structure of perceptual experiences – not only the specific contents they present, like a cat or a coffee cup, but how they unfold over time and space – my belief is that the apparent mystery of the hard problem is already beginning to dissolve. And this process gathers momentum when we ask who, or what, is doing all this perceiving – and consider the experience of being a conscious self from the same "real problem" perspective.

Contrary to how things might seem, selves aren't essences-of-you that peer out through the windows of the senses from somewhere inside the skull. Instead, the self is a perception too. Experiences of "being you" are collections of brain-based best guesses, and understanding this further erodes the dualistic intuitions on which the hard problem rests.

Just as consciousness has many aspects, there are also many ways we experience being a self. These can be arranged in a loose hierarchy, beginning with low-level experiences of being a physical body, through to experiences of ➤

"The mystery of the hard problem is already beginning to dissolve"

seeing the world from a particular first-person perspective, conscious intentions to do things (what we might call experiences of free will), all the way up to experiences of being a continuous person over time within a rich social and cultural environment – a self with a name, an identity and a set of memories. As I argue in my book, each of these aspects of selfhood can be understood as a distinctive form of controlled hallucination.

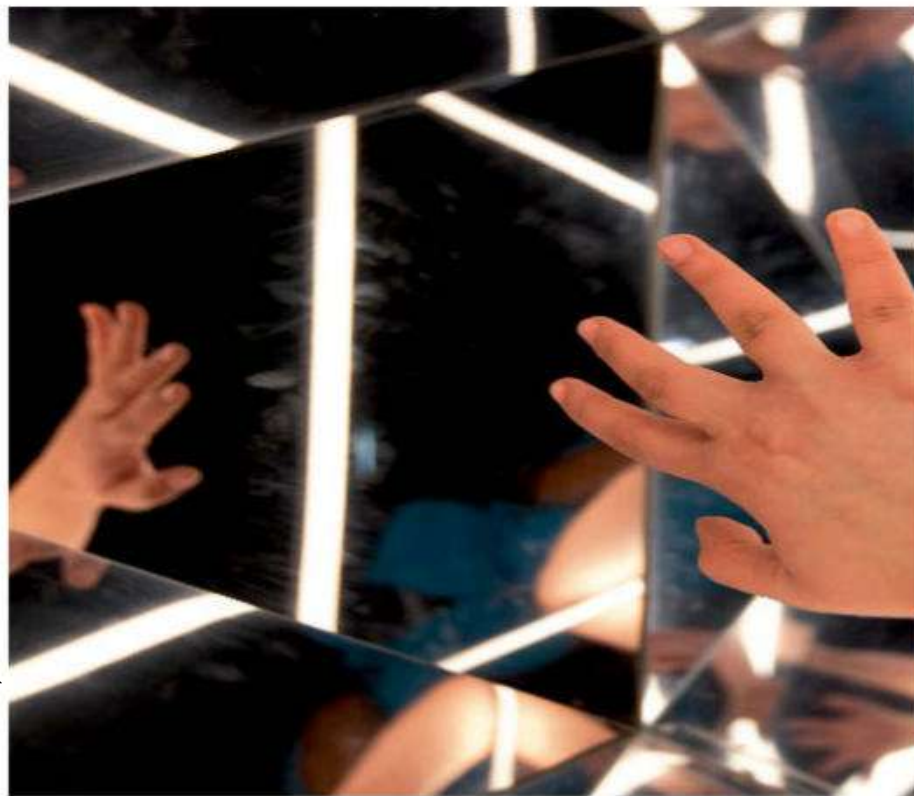
For now, let's drill down to the most basic aspect of conscious selfhood: the experience of being a body. I think of this as a rudimentary feeling of simply being a living organism – partly expressed through emotions and moods, but at its deepest layers without any describable content at all.

It is here that the perception of the body from within, known as interoception, comes to the fore. Interoceptive sensations tell the brain about the internal state of the body – blood pressure, say, or how the heart is doing – and therefore enable the brain to perform its most important task: keeping the body alive.

“Beast machines”

Like all sensory signals, interoceptive signals are only indirectly related to their causes, and so interoception must also involve a process of best-guessing. And just as inference about the causes of visual signals underpins visual experience, my proposal is that interoceptive inferences underpin other kinds of experiences: in this case, bodily experiences, like emotions and moods.

This proposal might seem nothing more than a modern gloss on some old ideas that emotion involves perception of changes in the physiological condition of the body. But there's more to it than that. Following the real problem strategy, the differences between emotional experiences and visual experiences can now be understood in terms of the different kinds of perceptual prediction at play. Visual experiences of objects are generally concerned with figuring out what's there, so it makes sense for the corresponding perceptual experiences to have the character of things with specific locations and physical extents. Emotional experiences, by contrast, are generally concerned with the organism's physiological condition and prospects of staying alive. These experiences, and experiences of being a body more generally, don't have shapes and locations in space – they instead have valence: which in psychology means things are good or bad now, or likely to be good or bad in the future. Which is what it is



PLAINPICTURE/JOHN-PATRICK MORARESCU

Our sense of self comes from how our bodies interact with the world

like to feel an emotion.

The upshot of all this is that the deepest layers of selfhood are intimately tied to our material nature as living creatures. The interoceptive predictions that underpin all self-related experiences are there to regulate our internal bodily state – to keep us alive. And from this, everything else follows. All our perceptions and experiences, whether of the self or of the world, are inside-out controlled hallucinations deeply rooted in the flesh-and-blood machinery that evolved, develops and operates from moment to moment in light of a fundamental biological drive to stay alive. We perceive the world, and ourselves, with, through and because of our living bodies. To repurpose another term from Descartes, we are conscious “beast machines” through and through.

“Experiences are controlled hallucinations rooted in flesh-and-blood machinery”

This way of thinking about consciousness and self transforms predictive processing from being a theory for consciousness science into a theory of consciousness – of why we are what we are and of the nature of all our experiences. There are many implications that follow from this. Most importantly, the connection between mind and life isn't only that apparent mysteries may dissolve when approached in the right way. There is a much deeper continuity to be found here, which implies in turn that consciousness may be more widespread among other forms of life than we think, and is less likely to shimmer into existence in the fleshless circuits of artificial intelligences, however advanced they may be.

The question I keep asking myself is where all this will lead. Will the hard problem dissolve entirely, vanishing in a puff of metaphysical smoke? Or will residues of mystery stubbornly remain? Either way, addressing the real problem of consciousness is likely to deliver much more progress than venerating it as a magical mystery or dismissing it as an illusory non-problem. This is the real promise of the real problem. Wherever it eventually takes us, the journey will transform our understanding of our conscious experiences of the world around us, and of our selves within it. ■



Anil Seth is a neuroscientist at the University of Sussex, UK. His new book *Being You: A new science of consciousness* is out now

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Somewhere, somehow inscribed in the brain is what makes you, you – your consciousness. But how do our brains turn mere electrical impulses into the vast range of perceptions, thoughts and emotions we feel from moment to moment?

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Puzzles

Try our crossword, quick quiz and logic puzzle **p53**

Almost the last word

What would Earth be like if life had never existed? **p54**

Tom Gauld for New Scientist

A cartoonist's take on the world **p55**

Feedback

A study about truth that turned out to be untruthful **p56**

Twisteddoodles for New Scientist

Picturing the lighter side of life **p56**

Stargazing at home

Finding the ice giants

It will soon be a good time to spot Neptune and Uranus, thanks to opportune positions in their orbits, says **Abigail Beall**



Abigail Beall is a feature editor at *New Scientist* and author of *The Art of Urban Astronomy* @abbybeall

What you need

A pair of binoculars

or a small telescope

A star chart (such as Stellarium, which can be found online)

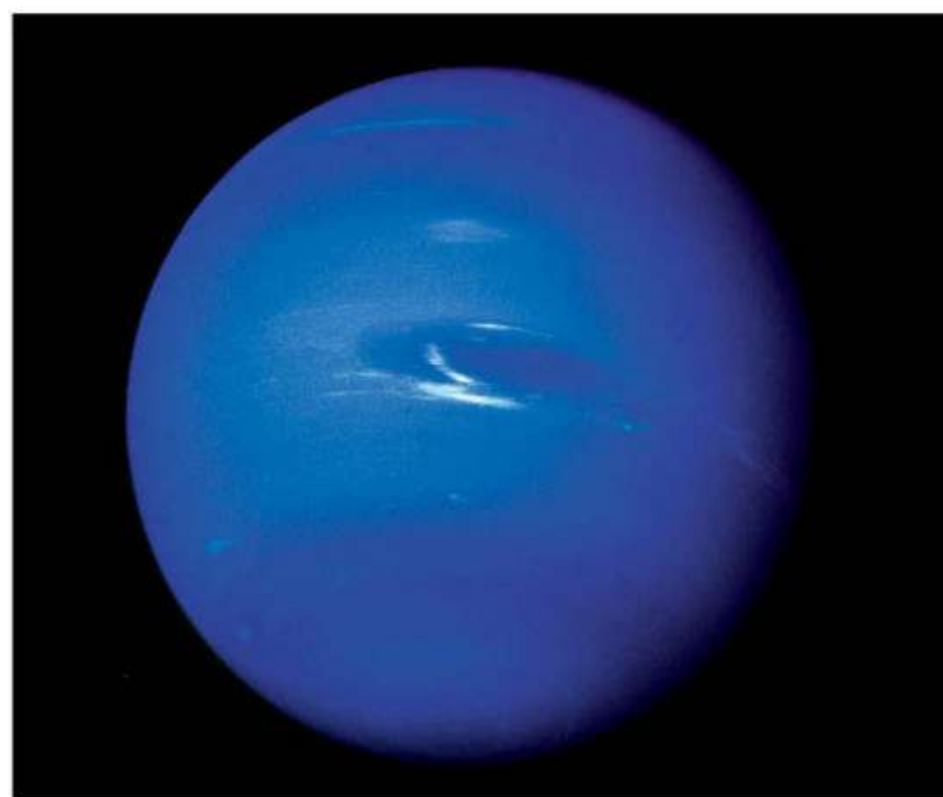
AFTER a few months of rising during the day, making them impossible to see, the solar system's biggest and most distant planets are once again visible at night. While Jupiter and Saturn are great targets to look for, shining brightly enough to see with the naked eye, the more distant ice giants are trickier to find. But if you have access to a pair of binoculars or a small telescope, you should be able to spot Uranus and Neptune (pictured) in the coming weeks.

Neptune is at opposition on 14 September, meaning that Earth will sit directly between it and the sun. Opposition is the best time to look for a planet, as it will rise when the sun sets and set when the sun rises, making it visible all night.

Neptune will be in the sky throughout September, so if you miss this specific day, don't worry. Another good time to try is 7 September, as there will be a new moon and dark skies will help in this endeavour.

It is impossible to see Neptune with the naked eye, so you will need a pair of binoculars or a small telescope. It is tricky to find, so a sky chart will help. There are plenty of resources online. I like the web version of the software Stellarium, because you can type in the location and time you want to stargaze and it shows you exactly what you should see.

In September, Neptune will be in the constellation Aquarius, near the star Phi Aquarii. Through binoculars, if you find Phi Aquarii



you should also see Neptune in the same view, although the planet will be much dimmer and will look like a faint star, rather than a disc. Neptune's blue colour will only be visible through a telescope.

If finding Neptune proves too tricky, there is another ice giant ready to be found. Uranus is much closer and brighter, making it easier to see.

If the skies are dark enough, Uranus should just be visible with the naked eye. It is at opposition on 5 November, which makes that the best night to look, but it will also be visible throughout September and October.

In September, Uranus will be between the Pleiades star cluster and the star Hamal, the brightest in the constellation Aries. Through

binoculars, you might be able to make out the greenish blue colour of the planet, caused by methane in its atmosphere.

If you have access to binoculars or a small telescope, point them towards Saturn or Jupiter and you will see much more detail. A small telescope will let you see the rings of Saturn and maybe some of its moons, while through binoculars you should be able to see some of the moons of Jupiter.

For the best chance of spotting Jupiter's larger moons, a resource like Stellarium will help you find where they will be in relation to the planet on the night you intend to look. ■

Stargazing at home appears every four weeks

Next week

Science of gardening

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 CLIMATE CHANGE IS REAL
 DINOSAURS HAD FEATHERS
 EVOLUTION IS A FACT

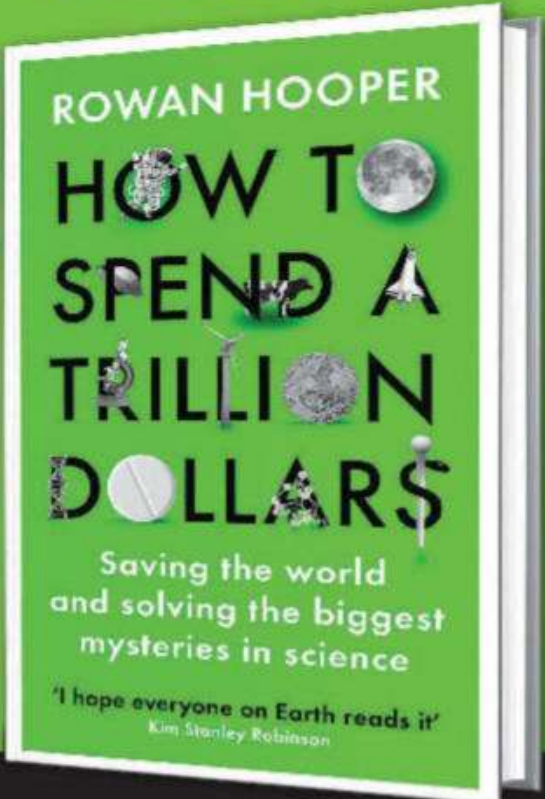


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Rowan Hooper doesn't have
a trillion dollars – but if he did...

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I hope it sells a trillion.'

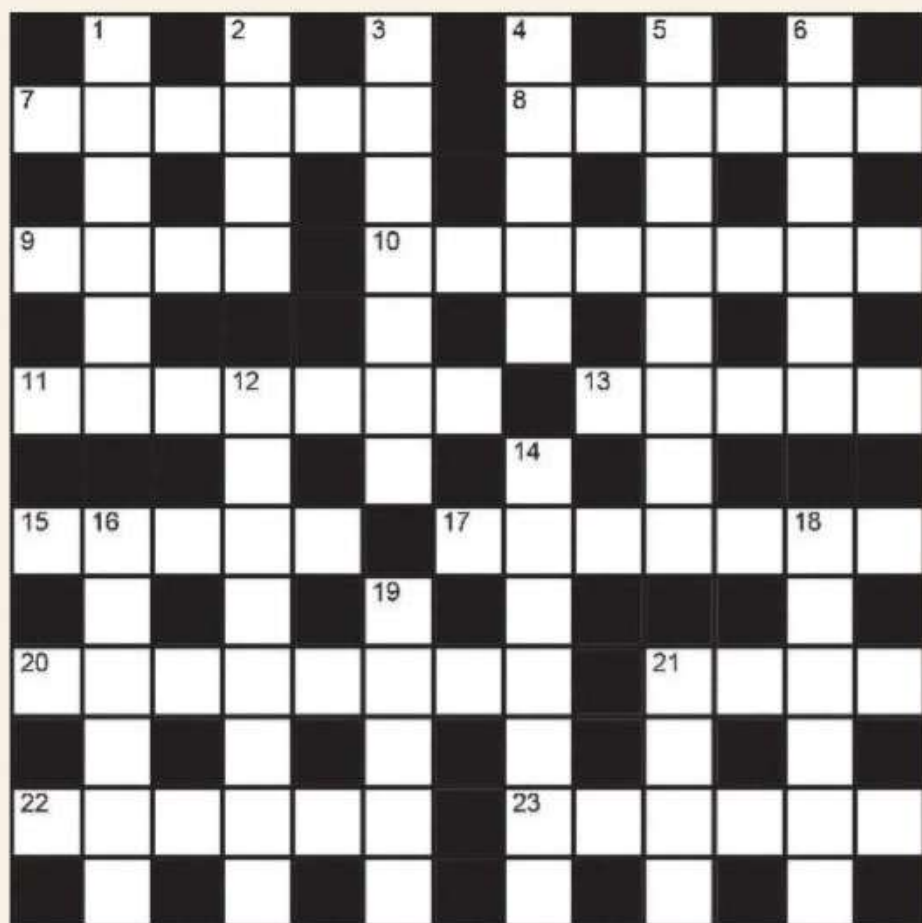
PHILIP PULLMAN



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Cryptic crossword #65 Set by Wingding



Scribble zone

Answers and the next quick crossword next week

ACROSS

- 7/10** Strange reason many had very mysterious illness (6,8)
8 Fuel putting energy behind Hawke, for one (6)
9 Kelvin and staff burning hydrogen and seaweed (4)
10 See 7 Across
11 Avoid Antoine Lavoisier's cause of death? (4,3)
13 Correctly wrote type of wheat (5)
15/18 Tory CEO has hotel rebuilt – could this predict seemingly random outcomes? (5,6)
17 Explosive record I tend to keep hidden (7)
20 Monkey finally found fruit (8)
21 Meat containing electron and oxygen-binding compound (4)
22 Layers of American pies flipped (6)
23 Sound effect related to part of speech (6)

DOWN

- 1** Georgia to dispense egg, maybe (6)
2 Distort conflict with power (4)
3 Edible plant surprisingly fails to be accepted by Syrian leaders (7)
4 Vessels of French wines containing stimulant (5)
5 Tango with brave man in front of dolphins and *T. rex*, perhaps? (8)
6 Creature lifting sheet (6)
12 Models and plays about Jupiter's moon (8)
14 Thinks queen's under water (7)
16 Hot planet where fire burns (6)
18 See 15 Across
19 Bird perched on a new moon (5)
21 Endless winter in French colony (4)

Quick quiz #117

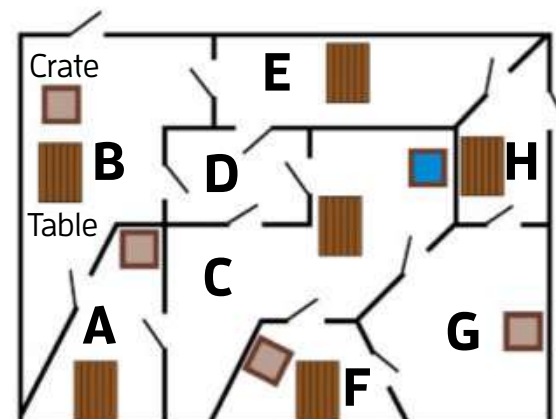
- Which group of animals has the highest hair density?
- Alexander Graham Bell and Elisha Gray filed for a patent and a patent caveat, respectively, for their telephone inventions on which day?
- Which type of volcanic eruption is caused by shallow waters and lava interacting?
- Tightly packed, roughly spherical collections of stars are known as what?
- What is the rarest naturally occurring element on Earth?

Answers on page 55

Puzzle

set by Brian Hobbs

#129 Dungeons & Diagrams



"How has someone left a shoe behind?" grumbles Bernie as he picks up the lost property after the latest team has left the Incredible Dungeon Escape Adventure. Bernie's job is to set up the dungeon between teams. Starting in one room, he walks through every door once, including the two external doors and the secret door in the wall directly behind one of the crates. He locks each door behind him and puts back all the furniture the previous team needlessly flipped over. Then he puts the Exciting Treasure Chest next to the table in the final room before leaving by the hidden trapdoor in the floor to take his 7-minute lunch break.

The contestants' map doesn't show the secret door or the trapdoor exit. Where did Bernie start, where is the treasure and how do you know?

Solution next week



Our crosswords are now solvable online

newscientist.com/crosswords

Lifeless planet

What would Earth be like if life had never existed?

Nick Canning

Coleraine, County Londonderry, UK

Earth would be a very different place to our familiar home if life had never existed.

The composition and chemistry of the atmosphere would be completely different, so this would profoundly affect the climate and the physical processes forming the land. If we were to visit such a place, we would surely find it a completely hostile and alien world on which we couldn't survive.

Although life began about 3.5 billion years ago, it largely remained single-celled and anaerobic for almost 2 billion years. When photosynthetic bacteria developed, they slowly changed the planet's atmosphere from one comprised of mostly carbon dioxide and nitrogen with trace amounts of oxygen to a more oxygen-rich one.

"If a lifeless Earth lost its magnetic field, it might look more like Venus or Mars, a nondescript brown"

This oxygen assisted the development of the more complex eukaryotic cell and so the eventual rise of multicellular life. It also precipitated out iron oxides, forming all those red soils around the world. Without that oxygen, there would also be no ozone layer filtering out damaging UV radiation.

With no life, the initial high levels of carbon dioxide would have remained in the atmosphere since no removal as marine carbonates could have occurred. So goodbye white cliffs of Dover in the UK and the limestone formations that make up our landscapes.

Life adapted to the planet and, in the process, radically changed it.



EDWIN GIESBERS/NATUREPL.COM

This week's new questions

Croaking in the rain Do frogs notice when it is raining?

Rachel Calam, Manchester, UK

Dying to be green Indestructible coffins aside, what is the most environmentally friendly way to deal with our bodies after death? Is burial better than cremation?

Jenny Jacoby, London, UK

Hillary Shaw

Newport, Shropshire, UK

Without life, Earth might be similar to Venus. There would be no oxygen, but abundant carbon dioxide, which could create a runaway greenhouse effect, evaporating the oceans. There would also probably be sulphur and nitrogen oxides in the atmosphere, resulting in sulphuric and nitric acid rain.

Plate tectonics might stall without oceans, so there would be no mountain chains, just large volcanoes punching through a global crust of granite, erupting infrequently but catastrophically. The vast range of terrestrial rocks we know today, including slate, limestone, chalk and all other sedimentary rocks, would be absent.

Mike Follows

Sutton Coldfield,

West Midlands, UK

Even if Earth were lifeless, its atmosphere and oceans would make it look pale blue. However, if it were to lose its magnetic field, Earth might look more like Venus or Mars (a nondescript brown) because the solar wind would remove the atmosphere and oceans.

Life that began on Earth between 3.5 and 4 billion years ago wasn't based on photosynthesis, and chlorophyll, a green pigment, didn't appear for another billion years. The land plants that colonised Earth and turned the continents green evolved only about half a billion years ago.

The appearance of a planet offers little clue to the presence of

Do frogs and other amphibians notice if it is raining or dry?

life, but analysis of its atmosphere might. James Lovelock, famous for his Gaia hypothesis, once worked for NASA and upset his employers by claiming that a mission to find life on Mars was a waste of money because there was no signal of life in the Martian atmosphere. In contrast, the composition of our atmosphere is far from a lifeless equilibrium; life on Earth is what keeps the concentration of oxygen close to 20 per cent.

Scientists haven't completely discounted the possibility of finding life on Mars, though there are more likely candidates within our solar system. It might be found on Europa, one of Jupiter's many moons, in hydrothermal vents on the ocean floors beneath its icy crust, with tidal heating providing the required energy. Life may also exist on Titan, one of Saturn's moons. These worlds might not seem like promising places for life, but looks could be deceiving.

Ancient aqua

How does water become "stale"?

Luce Gilmore

Cambridge, UK

Cold tap water contains dissolved gases, mainly carbon dioxide and oxygen. These are responsible for the popping noises a kettle makes as it heats up, since the solubility of gases decreases rapidly with temperature.

These gases have taste, but they also create a "mouthfeel", so give rise to different sensations. Water that is left in an open glass will warm up and lose dissolved gas, taking on an inert mouthfeel. I suspect this involves electrical conductivity. One reason why is because I have felt the same inert mouthfeel in tap water from Birmingham, UK, which comes from Wales and is very soft.

I grew up in Bedford, where not only is the water very hard, but it



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Tom Gauld
for New Scientist



also contains small amounts of iron from the Greensand aquifer. This means that its conductivity is high. It isn't to everybody's taste, but I like it. By comparison, I feel that Birmingham's tap water is like drinking polythene!

Chris Mosely
via Facebook

One organism's stale water is another organism's paradise. There are numerous definitions of stale depending on which organism you are in favour of.

Rashmin Patel
Gujarat, India

There are many reasons why water tastes stale when it is kept for a long time. Microorganisms play a big role in this phenomenon. When they grow, they release chemicals into the water from their metabolic activity. Algae make water smell earthy, for example.

The chlorine added to drinking water also affects its taste. This evaporates over time, so the absence of it from water left out for a long period brings about

"The gases dissolved in water have a taste, but also a 'mouthfeel', giving rise to a different sensation when drunk"

a change in taste. The temperature of water also influences its flavour, so warm water tastes different from cold.

Stephanie Stennett
via Facebook

"When it's not been flushed recently," says the dog.

Cross-legged

Is sitting with crossed legs bad for you? If so, why does it feel so comfortable (until your leg goes numb)? (continued)

Marie Rabouhans
London, UK

Have wires as well as legs become crossed? I suspect that the question was about sitting with legs crossed while the answers

relate to sitting cross-legged.

Sitting with legs crossed is a position commonly adopted in Western cultures when sitting on a chair. It involves crossing one leg over the other at the thigh and sometimes twining the foot of the upper leg behind the calf of the lower leg.

Women, in particular, have historically been led to choose this position for reasons of etiquette – it was deemed polite, "ladylike" and elegant (the opposite of manspreading?) and has been considered attractive by some. More recently, sitting this way has been discouraged on the grounds that it is bad for health, potentially causing problems with posture, circulation and blood pressure.

Sitting cross-legged, on the other hand, is a position adopted in many cultures when sitting on the floor. As pointed out in previous answers, this is widely practised, including as the "easy" seated pose in yoga and meditation. It is known as *sukhasana* in Sanskrit, meaning comfortable or joyful pose. ■

Answers

Quick quiz #117 Answers

- 1 Sea otters, with up to 150,000 hairs per square centimetre
- 2 14 February 1876
- 3 Surtseyan eruptions
- 4 Globular clusters
- 5 Astatine – only 25 grams of it are present at any given time

Quick crossword #90 Answers

ACROSS 1 Picotech, 5 Abacus, 10 Metro, 11/27 Renewable energy, 12 Calibrate, 13 Therm, 14 Streak, 15 Epizoon, 18 Alcohol, 20 Engram, 22 Regio, 24 Oxidising, 25 Darwinism, 26 Delta, 28 C-springs

DOWN 1 Pumice, 2 Catalytic, 3 Troubleshooting, 4 Car park, 6 Bowstring girder, 7 Cable, 8 Spermine, 9 Sneeze, 16 Oxacillin, 17 Oak ridge, 19 Leonid, 20 Enigmas, 21 N-grams, 23 Gorse

#128 Tournament headache Solution

There are six possible results: 0-0, 1-0, 1-1, 2-0, 2-1 and 2-2 and six games, so each result must have occurred once. Red Star Belgrad didn't concede a goal, so won two games (1-0 and 2-0) and drew the other 0-0, gaining 7 points. That leaves 1-1, 2-1 and 2-2 for the other matches. The team that won 2-1 must also have drawn 1-1, and earned a total of at least four points; neither of the last two teams can have earned more than three points. Therefore PSV Eindhoven, in finishing second, must have won 2-1 and drawn 1-1. The only remaining scoreline is 2-2, which was the result between Inter Milan and Tottenham Hotspur.

Honestly, gov'nor

Feedback hereby declares that, to the best of our knowledge, what follows is a true representation of whatever it is that follows. We find ourselves moved to this statement by a kerfuffle surrounding a scientific paper from 2012 entitled "Signing at the beginning makes ethics salient and decreases dishonest self-reports in comparison to signing at the end". Its authors included Dan Ariely, the Duke University psychologist who wrote the bestselling book *The (Honest) Truth About Dishonesty: How we lie to everyone – especially ourselves*.

The paper showed that requiring people to declare honest intent before filling in an official form made them more likely to complete it honestly than did the usual practice of making them sign to declare their honesty at the end.

In a subsequent investigation, the authors found they couldn't reproduce all the results. So far, so psychological science, where a 2015 study found that little more than one-third of studies stood up to further scrutiny. Eating from small plates doesn't make you eat less, and resisting marshmallows as a child doesn't make you a better adult, that sort of thing.

Now, however, another group of researchers have uncovered anomalies in some of the data about honesty declarations that they say suggests fakery. Cue widespread *schadenfreude* at honesty research being suspected to be dishonest.

This all reminds us of a 2019 study saying that non-experts could reliably tell whether the results of a psychology experiment could be replicated just by reading a short description and using their common sense. To the best of our knowledge, no one has yet attempted to replicate that finding. Signed and dated, Feedback.

Is it weathering?

For those overwhelmed by the complexities of weather forecasting relying on probabilities

Twisteddoodles for New Scientist



Got a story for Feedback?

Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT

Consideration of items sent in the post will be delayed

(14 and 21 August), Jenny Gretton of West Clandon in Surrey, UK, has a simple solution discovered when travelling in Canada in the form of the "Nova Scotia Weather Button".

"For the technically minded, it is a piece of card with a string loop at the top, and below the card a small section of a tree branch complete with bark," she says. "Instructions are: 'To use hang exactly eight inches from the house. By observing the following you can make weather predictions that are 100% accurate. If it is hard to see, it's foggy; if wet, it's raining; if white, it's snowing; if black, pollution is REALLY BAD; if swaying, it's windy; if missing – call the Police.'"

Neat, indeed, Jenny – we have already whittled our own to attach to our hat, which we intend to use for real-time forecasting when out and about.

Harboursing doubts

Renate Wood deepens our cultural understanding of what she terms UAMUs – Unusual Alternative Measurement Units – by pointing us to an ABC Radio Sydney website article claiming that "One Sydharb is an official Australian unit of measurement. It is used to measure volume and is equivalent to 500 gigitalitres, the volume of water in Sydney Harbour".

Our usual question of how many pints of Australian beer that amounts to applies (12 June). While wondering with Renate how the size of Sydney Harbour is relatable to those in the far-flung parts of Australia or elsewhere who have never seen Sydney Harbour, we do consider it very convenient of it to have adopted such a well-rounded size.

Rather as in the good old days, now sadly gone, of the metric prototype kilogram held in a vacuum-sealed container in a vault in Paris, we can only imagine the lengths, and depths, the authorities must go to in order to maintain the stability of the base unit – some dredging here, a nip and a tuck to the shoreline there. And climate change is going to be a beast to deal with.

Ger'off my land

Our item about crocodiles on a golf course (14 August) reminds Roger Lampert of St Albans, UK, of a sign he saw while out walking in the US some years ago. "It read 'Respect the rattlesnake's right to privacy. Stay on the path,'" he says. "I did." It's fair to say that sort of problem is rare in St Albans.

Elephant in the room

The prime natural hazard in southern England's New Forest National Park is overly skittish wild ponies, rather than rattlesnakes, or indeed elephants. But this doesn't stop Sam Edge, from Ringwood on its borders, writing to us in response to our item on thermal imaging cameras for detecting elephants (14 August). He suggests that the old joke on how to hunt an elephant needs an update.

For those in the dark, with or without an elephant, it is a "those scientists" joke: a mathematician will prove the existence of an elephant, and leave the detection and capture of an actual elephant as an exercise for a student; an engineer will take anything greyish within 15 per cent of the standard weight, and so on.

Looking through the list, we see it sadly lacking in some disciplines. A psychologist might, we speculate, not actually directly observe an elephant, but see a correlation in the data that definitely indicates an elephant, except on further scrutiny it turns out it was a chihuahua. Further suggestions for other areas of scientific endeavour welcome. ■

GALAXY

ON GLASS

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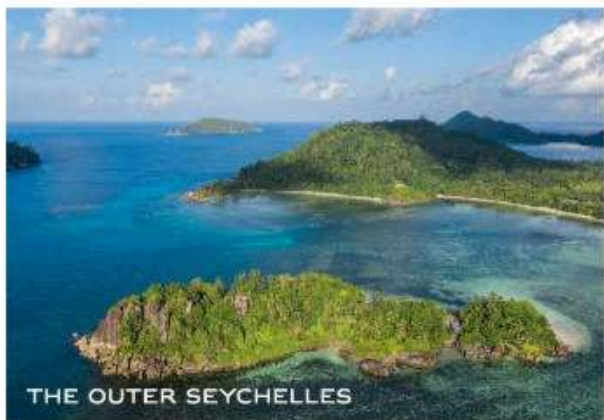
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ON OUR WATCH

Hope can now be spotted across all our planet's seas and oceans. Sites are made into aquatic havens by local communities, to safeguard the richness and diversity of the ecosystems they depend on. Sylvia Earle's invaluable experience as an explorer and marine biologist continues to help further their goal, through her organisation, Mission Blue. Together, they have created over 130 Hope Spots and counting. Carrying a message of hope for generations to come. It is that vision, that dedication to a perpetual planet, which we are proud to stand by. For as long as it is needed.

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